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ANNALS *of* SURGERY

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CONGENITAL VARIATIONS IN THE PERITONEAL RELATIONS OF THE ASCENDING COLON, CÆCUM, APPENDIX AND TERMINAL ILEUM

BY SAMUEL CLARK HARVEY, M.D.

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I. INTRODUCTION

IT is customary to consider that peritoneal adhesions result from peritoneal inflammation and represent a reaction on the part of the peritoneum to injury. Such an injury may be mechanical, as paracentesis, operative damage, etc.; chemical, as the so-called toxic inflammation in Bright's disease, etc.; parasitical, as in infection of the peritoneal cavity,[a] or coincidental to inflammation of contiguous viscera. The etiology is easy to ascertain in the majority of instances, and even in the more puzzling conditions, association with lesions elsewhere or a very definite anatomical picture renders the classification not difficult, as in polyserosites,[3, 4] chronic hemorrhagic peritonitis, and peritonitis productiva or obliterans. This is especially true of the adhesions noticed in the course of the cursory examination of the peritoneum usually employed at necropsy. If, however, one examines with care certain portions of the peritoneum and especially those portions in the neighborhood of the ascending and transverse colon, not only adhesions of very apparent inflammatory origin but also "idiopathic adhesions" and variations in the peritoneal reflections appear with such frequency that one is tempted to consider such structures as normal, or if abnormal the result of some pathological condition surprisingly prevalent.

It is our intention to discuss the origin, frequency of occurrence and significance of this particular group of adhesions, together with supposedly associated variations in the position of the colon.

II. HISTORICAL

For an intelligent discussion of this subject, a proper historical perspective is invaluable, not only as regards the inflammatory structures, but especially in connection with the abnormalities arising during the course of the development of the intestine. The development of the intestine, the

[a] For a general discussion of peritonitis see von Brunn[1] (1885–1900), Nothnagel.[2]

formation of its mesentery and its relations with the surrounding organs is a subject that has been pregnant with interest for many generations. Casual references are not infrequent in the works of the older anatomists. Galen [b] refers to the mesentery as a "peritoneum duplex" and Morgagni describes in many cases adhesions of the peritoneum.[6] With the beginning of the nineteenth century this interest became accentuated. John Hunter,[7] in 1802, first noted in the embryo of man the close relationship of the intestine to the umbilical cœlom and this was described in detail by Meckel,[8] in 1817, to whom we owe the greater part of our knowledge of the diverticulum which bears his name. The work of the latter was not, however, confined to the description of this one anomaly, but included the first detailed account, founded upon careful observation, of the embryonic development of the intestine and the great omentum. Until the time of Toldt it was to remain the authoritative work upon this subject. At about this same time Fleischmann [9] wrote concerning anomalies in the position of the colon and in the peritoneal attachments, which, after the examination of many fœtuses of four to seven months of age, he attributed to variations in the development of the intestines. This is the first detailed study of this subject from the standpoint of pathology.

The clinical importance of displacements of the colon received its first adequate emphasis by Esquirol,[10] in 1838, who noted at necropsy 33 displaced coli in 168 cases of melancholia, of which many were the V-shaped transverse colon, now so familiar. The association of this condition with mental derangement had been for many generations a medical tradition, but never previously so well demonstrated.

From the anatomical side, J. Müller [11] in 1830 published an epochal paper concerning the origin of the omentum and the mesentery of the stomach and intestine. This was soon followed by many attempts at detailed descriptions of the abdominal viscera and their peritoneal coverings, of which Huschke's [12] are the most interesting. In 1845, in Soemmerring's "System of Anatomy," he described in considerable detail the ligaments or peritoneal folds about the liver, gall-bladder and duodenum which have collectively and deservedly come to be known as the ligaments of Huschke. In particular he mentions the "ligamentum hepatico-duodenale" and the "ligamentum hepatico-colicum," the clinical significance of which is now being recognized, long after its anatomical recognition had in greater part been forgotten. Huschke also called attention at this time to the fact that the cæcum rarely has any mesentery, a point which has often been reiterated and, as a perusal of the literature on the subject of "cæcum mobile" shows, needs to be still reiterated. He also contributed the first extensive account of the folds and fossæ about the ileum and cæcum.

Meanwhile the interest of the great pathological anatomists, Rokitansky [13] and Virchow,[14] had been aroused, but apparently without proper appreciation of the anatomical work already done.

[b] For an historical discussion of the literature up to 1879, see Toldt.[4]

The former, in 1842, noted in careful observations on almost innumerable subjects, peritoneal adhesions sufficiently characteristic to enable him to classify them as: between adjacent loops of intestine; between intestine and adnexa; and between intestine and parietal wall. These he presumed to be of inflammatory origin. To Virchow, however, must be given all credit for a most careful and detailed report of such adhesions, in a classical article published in 1853 and intitled "Historisches, Kritisches und Positives zur Lehre der Unterleibsaffectionen." Localized adhesions at the sigmoid flexure, at the left and right colic flexures, about the gall-bladder, duodenum and pylorus, and of the greater omentum to the parietal wall are all here definitely described. The process by which such adhesions were formed was termed "chronische partielle Peritonitis" and led, not infrequently, to kinking, axial rotation and partial obliteration of the intestine. Such peritonitis was supposed to be secondary to an inflammation resulting from the stagnation of fæces, the latter being a result of anomalous positions of the intestine previously described by Esquirol and Fleischmann.

The next contribution of note was made by Engel [15] in 1857, who in a series of papers concerning the cæcum noted abnormal mobility in, roughly, 10 per cent. of some 100 necropsies.

The same year Treitz [16] published the first systematic study of retroperitoneal herniæ with the fossæ and folds involved. This was destined to awaken a virile interest in this topic and to be succeeded by many other treatises of a similar nature. In this monograph he described in considerable detail the fixation of the colon, which he considered to be due, as previous authors had suggested, to the relatively greater growth of the structures in the posterior abdominal wall, thus resulting in the spreading out of the mesenteric leaves and the approximation of the colon to the parietes.

This general principle as enunciated by Treitz reappears again and again in the more recent discussions of the relation of the colon to its peritoneal covering, apparently without knowledge of Treitz's contribution. He also describes in greater detail the subcæcal fossæ to which Huschke called attention and in connection with the descent of the cæcum refers to the presence of a "plica genito-enterica" which has the "Bedeutung eines wahren Leitbandes für den Blindsack und das unterste Ileum." He also suggests that this same fold, which he believes to be a vestige of the descent of the testicle or ovary and to act as a guide and tractor for the descending colon on either side, is the essential factor in the formation of the "Recessus intersigmoideus." Although agreeing with Virchow that many of the adhesions about the colon are inflammatory in origin, he asserts that those in the region of the sigmoid are due to the peritoneal rearrangement involved in the formation of the intersigmoid fossa.

Luschka,[17] in 1861, and Langer,[18] in 1862, wrote concerning the fixation of the colon, and the formation of the folds and fossæ adjacent to the cæcum. The former described the ileocolic fold which properly bears his name,

while the latter discussed in particular the relation of the greater omentum to the colon in respect to its fixation. He was of the opinion that the ligamentum phrenico-lienale, as well as the corresponding fixation of the colon on the right, was derived from the omentum which by its attachment to the parietal wall served to fix the colon. He even went so far as to attribute the position of the fossæ subcæcales and the bands frequently seen in the neighborhood of the sigmoid to this same omental fusion.

Waldeyer,[19] in 1868, discussed Treitz's hypothesis on the basis of numerous observations of his own, and concluded that the development of the fossæ and folds previously described could not be thus easily explained. As for the more unusual bands which he likewise observed, these were considered as perhaps the result of a fetal peritonitis or of some as yet not understood factor.

Gruber,[20] at about this same time, was publishing a series of articles having to do with the anomalies resulting from incomplete development of the intestine and its peritoneum. In these the "mesenterium commune" received its first extensive consideration.

The year 1879 marked the publication of a notable paper by Toldt [5] on the "Bau und Wachsthumsveränderungen der Gekröse des menschlichen Darmkanales," the importance of which cannot be too greatly emphasized. The fundamental character of this work can be properly appreciated only by reading the original paper. The description to be given later of the developmental changes in the intestine and mesentery will be founded in large part upon the work of Toldt. Only a few of the points of special interest will be referred to at this time.

Detailed examinations were made of some eleven embryos under six months of age and twenty-four during the last three months of intra-uterine life. Sixty infants under one year of age and fifty-four children from one to twenty years were also examined. He concluded that the mesenteries of the colon disappear by a process of "physiological fusion" of contiguous peritoneal surfaces. The adhesions noted previously by Treitz [16] and Waldeyer,[19] as well as many described by Virchow,[14] were considered to be the result of this process rather than of a fetal peritonitis. The great omentum in either flank serves, by its adherence to the parietal wall and to the intestine, to aid in the process of fixation. The colon and its peritoneal relations after birth show great variations, and developmental changes occur for some time during infant life. The colic omentum on the right may persist as far as the cæcum, become attached to the parietal wall or fused across the hepatic flexure with the great omentum. The ligamenta cæcæ and the fixation of the ileum are the result of developmental variations, and this is likewise true of the not infrequent adhesions observed about the appendix. The hypothesis accounting for the formation of the mesentery by the approximation of two leaves of the peritoneum was entirely refuted as well as that of the fixation of the colon by disproportionate growth and spreading of the mesentery. In short, Toldt described most of the forms of intestinal and

peritoneal aberrations to be discussed in this present paper and referred these to variations in the normal process of development.

In 1885 [21] the first extensive consideration in the English literature of the anatomy of the intestinal canal in man was contributed by Treves in the Hunterian Lectures of that year. The development of the intestine immediately after birth was especially considered and valuable data given as to the frequency of occurrence of the ascending and descending mesocoli, mobile cæcæ, etc. The various folds and fossæ of the peritoneum were also discussed, in particular the so-called "bloodless fold of Treves," but with little reference to previous work done on this subject. It is of interest to note his statement that "in not a few specimens the terminal part of the small intestine has been closely attached to the psoas muscle, not by direct adhesion but by a fold of peritoneum." This work was peculiarly fortunate in appearing within a year of Fitz's elucidation of appendicitis and provided very valuable data in the English literature covering the anatomical problems presented by this condition.

The studies of Treitz, Luschka, Waldeyer, Treves, and many others in respect to retroperitoneal herniæ, together with a large amount of personal work, were embodied by Jonnesco [22] in a monograph entitled "Hernies internes retro-péritonéales," published in 1890. This in conjunction with a second article by the same author in 1894,[23] dealing more particularly with the folds and fossæ about the appendix and ileum, comprises a complete exposition of this subject. He is unusually conscientious in his references to work previously done.[c]

Klaatsch,[26] in 1892, wrote concerning the morphology of the mesentery and its development in the vertebrates. This forms the first extensive account from the standpoint of comparative anatomy and with Huntington's [27] monograph (1903) serves to corroborate and correlate the findings of Toldt with the changes noted in the lower animals. Mall,[28] in 1897, by accurate reconstruction studied the development of the intestine and mesentery in the embryo very early in life, thus filling in a gap in the work of Toldt.

Lockwood and Rolleston,[29] in 1892, investigated 160 bodies in which there was no peritonitis or sign of local inflammation. Of these 23 per cent. were found to show adhesions of the appendix to neighboring structures, referable to abnormalities of development. The hypothesis of Treitz that the plica genito-enterica acts on the cæcum as a tractor to guide it into position was for the second time [30] advanced by this author with no reference to work previously done.

Addison,[31] in 1900, studying the intestine and mesentery in 40 cadavers, supplied additional data as to the frequency of occurrence of already well-

[c] Shorter but admirable discussions of this same topic are available in the English literature, notably Moynihan's [34] "Retroperitoneal Hernia" (1906) and Berry's [35] "The Cæcal Folds and Fossæ and the Topographical Anatomy of the Vermiform Appendix" (1897).

recognized variations of the intestine. Another contribution of the same nature was made by Byron Robinson [32] in 1902. Both of these writers dealt in detail with abnormal mobility of the cæcum and colon and with the bands and ligaments of peritoneum which are at present under discussion, and the former very specifically describes the hyperfixation of the ileum now known as Lane's band.

At about this period, from the clinician's viewpoint, pain in the right lower abdomen came to mean appendicitis—if unaccompanied by acute illness "chronic appendicitis"—and most surgeons and many pathologists assumed the membranes not infrequently seen about the intestines on this side of the abdomen to be the residuum of an appendicitis.

It is true that some unusually keen observers had begun to suspect that such membranes might give symptoms of themselves, identical with those of "chronic appendicitis." Riedel, as early as 1894,[33] called attention to this, and in later papers, in 1897,[34] and 1898,[35, 36] again and again in great detail described omental, gall-bladder, appendiceal, colonic and ileal membranes in connection with colicky pain and other symptoms of partial obstruction. These descriptions were particularly accurate and his work deserves greater credit than has as yet been given it. He thought that in the new-born such structures might occur as a primary developmental error, but that in the adult it was quite probable that they might arise from chronic inflammation. Riedel also considered that such membranes might be due to the dragging of the colon upon the mesentery, with the rupture of supporting fibres, and their accentuation by the consequent repair. He thus antedated all the present hypotheses by several years.

In 1893, Lauenstein,[37] whose attention had been attracted by the work of Riedel, reported many cases with the symptomatology of "chronic appendicitis" in which he found membranes about the gall-bladder, ascending colon and particularly the ileum, of which he gave diagrammatic sketches. He reported surgical treatment of these bands and membranes with cures thereby.

A new phase of the subject was introduced by Curschmann [38] in 1894, who described several cases in which the cæcum was turned upward with a sharp kink, causing partial obstruction, in his mind the cause of this being anomalies of the mesentery of the colon.

Although Riedel referred to adhesions on the left side of the abdomen, it remained for Gersuny,[39] in 1899, to call adequate attention to their frequency and their significance. He noted that patients giving the symptoms and signs of a "chronic appendix" on the left side of the abdomen, frequently showed at operation adhesions about the sigmoid flexure, and that the release of these, in some cases, effected a cure. Their origin might be from an old appendicitis with healed peritonitis, from inflammation of the adnexa, or from the rupture of ovarian follicles and resultant hæmatomata in this region.

Likewise, Quénu,[40] in 1902, covering more intensively some of the ground

previously considered by Riedel, discussed stasis at the left colic angle as a result of omental adhesions stretching across it, a subject which was to be even more extensively considered by Payr in 1905,[41] the latter supposing them to be the result of chronic inflammation. In a second paper[42] in 1913 he, however, recognizes the congenital type as well.

Tavel,[43] in 1904, reported instances of adhesions over the ascending colon and with the omentum where the "cæcum vagabundum" of Roux was present. The diagrammatic pictures accompanying this article well illustrate what is now known as "Jackson's membrane." In 1905 appeared the first case report in the American literature of this type of a lesion (Binnie[44]). Apparently, however, no great importance was laid upon the presence of this membrane either by the author or by his readers.

In 1905, also, Corner and Sargent[45] published in this country five cases of volvulus of the cæcum (cæcum mobile) with a collection from the literature of 52 similar lesions. Dilatation from partial obstruction was present and at times gave rise to symptoms suggestive of appendicitis.

At this same time a paper by Hockenegg[46] emphasized the importance of appendiceal colic as distinguished from appendicitis, and the result of abnormal fixation of the appendix, probably congenital. This condition corresponded with the "appendicitis larvata" of Ewald or the "pseudo-appendicitis" of Nothnagel.

Meanwhile Wandel,[47] in 1903, in 640 necropsies had paid particular attention to the position of the cæcum and the presence of abnormal mobility, especially with reference to kinking, torsion or marked displacement. In 66 of these the cæcum was mobile, 28 being in children, an incidence distinctly higher than in the adult.

During this time surgical experience as regards the appendix was becoming crystallized. The rapid method of operating through a "button-hole" incision was falling into disrepute, in part because such procedure did not allow of a satisfactory exploration of the abdomen for lesions, such as cholecystitis or peptic ulcer which might simulate a chronic appendicitis. It also began to be noted by observers whose object was the ultimate condition of the patient rather than the success of the immediate operative procedure that in many instances the symptomatology of "chronic appendicitis" was followed by the discovery at operation of a normal appendix and that the removal of this organ usually failed to alleviate the symptoms of which the patient originally complained. Such a general impression was confirmed by statements of end-results by such surgeons as Haberer[48] and Klemm.[49]

Haberer, in 1905, reported 116 cases with the clinical diagnosis of "chronic appendicitis," in 40 of which the removal of the appendix did not relieve symptoms. Many of these showed at operation membranes about the cæcum and colon which he supposed to be the result of an appendicitis or cholecystitis, usually the former.

Two years later Klemm called attention to "anfallsfreie Appendicitis,"

in connection with which he observed membranes about the cæcum and colon and dilatation of the cæcum. Like Haberer, he ascribed these conditions to inflammation of the appendix, but noted that in many instances removal of this supposedly diseased organ did not effect a cure. Albu [50] at this same time reported cases of " chronic appendicitis " in which the appendix was normal. He thought the pain possibly due to kinking of the appendix.

Such observations were by no means unusual, and from 1905 to the present time the history of this topic presents a medley of descriptions and hypotheses of various abnormal structures described and discussed by numerous workers, many of them in apparent ignorance or with inadequate appreciation either of what had been done previously on this subject or of what was being done elsewhere at the time. The springing up of such a crop of observations served to demonstrate, however, the general opinion as to the inadequacy of our knowledge concerning the conditions which may simulate the so-called " chronic appendicitis."

In analyzing the work accomplished in the past ten years one finds that it falls naturally into three groups, of which Wilms in Germany, Lane in England, and Jackson in this country may be taken as the representatives. These men have served to call attention to facts well recognized previously but not properly emphasized from the clinical point of view, and they deserve much credit for thus attracting the attention of the profession to this subject.

Lane [51] as early as 1903 began to discuss the presence of membranes about the colon and ileum, and their significance in chronic intestinal stasis. With the development of his interest in this subject, successive papers and monographs have appeared,[52, 53, 54, 55, 56, 57, 58] the latest being but a statement of his position, which reached its fullest development from 1908 to 1911. His attitude toward the etiology of these structures seems to have been largely determined by his early studies on the adaptation of tissues to increased work, as in the bony attachments of muscles, and from this he has evolved the idea that the membranes and bands about the colon are but an evolutionary response to the erect position, which results in a " crystallization of the lines of strain." His extreme enthusiasm as to his operative results has served to call attention to a subject which perhaps otherwise would have been for a long time neglected.

During the same period Wilms [59, 60, 61] was attacking the problem over a smaller field, and from a somewhat different angle, this being also apparently determined by early work of his on the sensitiveness of the peritoneum and mesentery to pain. The pain observed in the so-called " chronic appendicitis " seemed to him referable to the dragging on the mesentery by an unduly movable cæcum, and an investigation of this in the course of operations for " chronic appendicitis " provided material for his report of 40 cases of " cæcum mobile " operated upon with fixation of the cæcum and with good results. This publication aroused much interest and considerable discussion in Germany, and led to the publication of valuable papers by Fischler [62] on " typhlatonie," Klose [63, 64] on "habitual torsion," and Stierlin,[65] who in 1910 reviewed the work in Wilms' clinic.

Meanwhile, Jackson,[66] in 1908, had described in detail a case of "chronic appendicitis" with a veil-like membrane over the ascending colon. Similar structures were almost immediately noted by many abdominal surgeons and the literature for the next few years teems with descriptions of these.

Hofmeister,[67] in 1911, viewed the subject from a point that at that time was receiving its greatest attention in America; namely, the presence of adhesions about the colon. The greater number of the laparotomies performed for chronic abdominal pain, in his opinion, revealed a healed acute appendix which had never given the symptoms of an appendicitis, the "anfallsfreie Appendicitis" of Klemm. There might be microscopically or macroscopically no sign of inflammation in the appendix, but the membranes over the colon and about the cæcum were taken to be evidence of such a condition in the past. Moreover, these bands, according to Hofmeister, were capable of producing dilated and mobile cæcæ subject to torsion and kinking. In short, the process, in his mind, was definitely inflammatory following a colitis, or appendicitis and a consequent pericolitis. In the same year Dreyer [68] in 105 autopsies reported 67 per cent. of movable cæca and furnished a complete review of the literature on "cæcum mobile."

It was at once apparent that the determination of the etiology of these structures had an important bearing on the treatment to be adopted, and consequently nearly every writer has ventured an opinion on this particular phase of the subject. The simplest explanation, and the one for a time most frequently offered, attributed the condition to inflammation. An appendicitis, or a colitis, or a primary pericolitis was presumed to have been the etiological factor by Gerster,[69, 70] Frazier,[71] Morris,[72] Coffey,[73] Martin,[74] Bevan,[75] Cuneo,[76] Eastman, [77] and by Pilcher [78] in his first paper.

On the other hand, C. H. Mayo [79] early pointed out that both the "Jackson membrane" and the "Lane band" were probably congenital, and Connell [80] reviewed the development of the intestines and peritoneum, showing the variations which these structures represented. It remained, however, for Flint,[81] in 1912, to show conclusively that such structures observed in the operating room were identical with certain peritoneal malformations found with great frequency in the fœtus. At the same time Gray and Anderson [82, 83] reported similar observations in the fœtus and arrived at the same conclusions.

Meanwhile, Douglas Reid [84, 85, 86, 87] had been reporting many variations of the normal peritoneal folds in cadavers, some of fœtuses, studied by him. These observations were in fact but repetitions of similar findings reported by many anatomists in previous years, but coming at this time they served to form the basis of a further development of the congenital theory which supposes these membranes and bands to be but modifications of folds previously described. "Jackson's membrane" becomes "Jonnesco's parietocolic fold," adhesions about the cæcum "Treves' bloodless fold," and "Lane's band" "Reid's genito-mesenteric fold." Cheever [88] and Eastman [77] in particular have emphasized this phase of the subject.

More recently W. J. Mayo,[89] Morley,[90, 91] Barling,[92] Summers,[93] Moynihan,[94] and Eisendrath and Schnoor [95] have stated that these membranes are congenital. Morley and Eisendrath and Schnoor in particular based their opinion upon the findings of these structures in fœtuses and infants. Leveuf,[96] in France, has also called attention to the presence of such structures in the fœtus and again to the persistence of the colic omentum of Haller and its relationship with the formation of membranes about the ascending colon. Keith [97] has approached the problem from quite a different angle, and states that, the adhesive process being an embryonic property, variations in this process resembling adhesions are not surprising. Such variations, however, in his opinion, have but little influence on the normal function of the gut. Stasis is due not to these structures, but rather to a loss of function of certain ganglionic centres in the wall of the intestine normally responsible for its peristalsis.

In spite of the preponderance of evidence already offered by the advocates of the congenital formation of these membranes, it seemed worth while to supplement the data of Flint, Gray and Anderson, Morley and Leveuf by the examination of the intestine and peritoneum in a large number of infants shortly after birth, and especially with a view to relations of the membranes to each other, to the mobile cæcum, to sex, and to the age of the infants. It was assumed, for reasons which will be discussed fully later, that any variations from the normal in the position of the gut and its peritoneal attachments seen at this age might be considered as arising from variations during the development of these structures.

For a proper appreciation of the data presented, it is necessary to have clearly in mind the developmental history of the peritoneum and intestine and their relations to adjacent structures at varying periods of embryonic life.

III. DEVELOPMENT OF THE INTESTINE

At about the sixth week of intra-uterine life the alimentary canal has reached a stage of development indicated in Fig. 1. The stomach and intestine lie in the midline, the greater diameter of the former being directly anteroposteriorly, and the latter projecting forward toward the umbilical cœlom from which it has just been withdrawn.

At about the third month we find certain important changes taking place. The stomach undergoes a rotation by which its greater curvature comes to lie toward the left, and its lesser toward the right, the peritoneal attachment of the latter thus forming the hepatico-gastric omentum. The duodenum likewise undergoes a similar rotation and, in addition, the posterior layer of its mesentery, by a process of fusion with the peritoneum of the posterior abdominal wall, becomes fixed. The rapid growth of the intestine has meanwhile carried the cæcal bud upward into the upper part of the abdomen and the condition is now that represented in Fig. 2. By the fourth month the growth of the portion of the colon which will shortly become the ascending and transverse colon has carried the cæcal pouch upward and to the right. With this there is a consequent rotation upon its

own axis, so that the ileum, which has previously entered from above and to the right, now is seen below and to the left of the cæcum (Fig. 3).

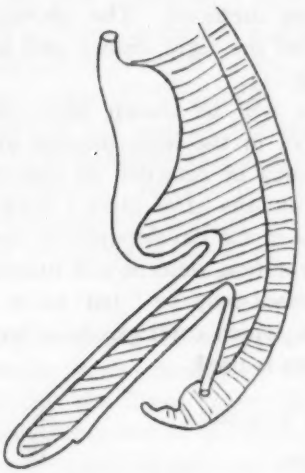

FIG. 1.—Intestine of fœtus at about sixth week (after Toldt).

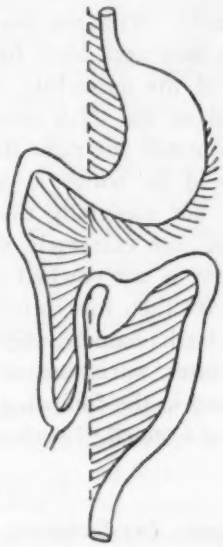

FIG. 2.—Intestine of fœtus at about third month (after Toldt).

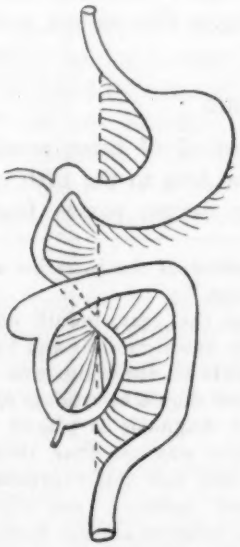

FIG. 3.—Intestine of fœtus at about fourth month (after Toldt).

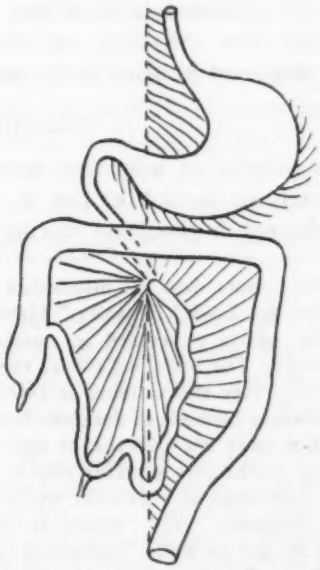

FIG. 4.—Intestine of fœtus at about eighth month.

Toward the end of this month the process of fusion of the mesentery is rapidly accentuated, the mesocolon at the hepatic and splenic plexus disap-

pearing and the great omentum which has been formed by a bulging of the posterior mesogastrium becomes attached along the transverse colon and at times over the ascending colon and cæcum even to the appendix (Toldt and Prenant). This reaches its highest point at about the seventh month. From this time until birth fusion progresses slowly with the gradual disappearance of the ascending and descending mesocoli. The cæcum meanwhile at about the sixth month has reached the right kidney and at about the eighth month the right iliac fossa (Fig. 4).

It should be borne in mind that, as will be shown later, all these processes, but especially those most active in the later months of intrauterine life, are extremely variable and may be retarded so that the full development is not reached until several months after birth (Toldt).[d]

There are then four processes involved in the development of the colon as seen at birth; namely, migration, axial rotation, descent and fixation. As Prenant states, variations of these processes may be "par excès et par défaut," and in the following classification, which corresponds in large part with that of Connell,[101] such an arrangement is used.

IV. CLASSIFICATION AND DATA

Migration: (*a*) Deficient, (*b*) excessive.
Rotation: (*a*) Deficient, (*b*) excessive.
Descent: (*a*) Deficient, (*b*) excessive.
Fixation: (*a*) Deficient, (*b*) excessive.

In the appended table giving the essential data concerning the cases examined, these variations are classified according to this outline, and they will be discussed in detail under these headings.[e]

V. VARIATIONS OF MIGRATION

The process of migration extends over a period of three months or more, early in fœtal life; that is, from about the first to the fifth month, when descent begins, and during this time the cæcum passes from the

[d] For a more detailed discussion of the development of the intestine and its mesentery see Toldt,[8] Broesike,[88] Hertwig,[89] and Prenant.[100]

[e] The age is expressed in numbers representing the year, month and day respectively. For instance, 1–7–14 represents one year, seven months and fourteen days. Wherever this number is asterisked it represents an approximation of the age, necessary because of deficient hospital records, and should be read as follows: 0–6–0—not over six months of age. Wherever the diagnosis is placed within quotation marks this signifies that a complete necropsy was not done, that there was no pathological condition within the abdomen and that this represents the clinical diagnosis. The variations when present are marked *, and signify a kink in the gut as well. Variations of migration and rotation are not included in this table, as they are so few that it is not worth while tabulating them. They are discussed under their appropriate headings. The terms "hypodescent" and "hyperfixation," etc., although not ideal from the standpoint of derivation, are convenient and will be used throughout the remainder of this paper. The headings under hyperfixation refer to the location of the adhesions and are explained in

umbilical cœlom into the abdomen, then upward and to the right until it comes to lie in the right hypochondrium. Variations from this procedure might be theoretically of two types: the intestine might remain in whole or in part without the abdominal cavity or pause at any point along the route (deficient migration); or it might move downward prematurely into its adult position (excessive migration). The latter could only be detected by examination previous to the time of normal descent and consequently does not appear in these data. The former, in which the cæcum may be found in the left side of the abdomen or even in a congenital umbilical hernia, is exceedingly rare and was not observed in this series of cases. Smith,[103] however, reports five instances of deficient migration in the course of 1050 autopsies on infants, or in one-half of one per cent., and the condition is, of course, a matter of common surgical knowledge.

VI. VARIATIONS OF ROTATION

The process of rotation is practically synchronous with that of migration, and consists in the turning of the gut upon its longitudinal axis in such a manner that the ileum enters the large intestine on its left side, whereas previously it entered on the right. The variations in this process which are theoretically possible are: (*a*) deficient rotation, (*b*) excessive rotation. In the former case the ileum would enter from the right and posteriorly, and in the latter anteriorly. One instance of deficient rotation was observed in this series, occurring in a female under one month of age in whom no cause of death was found (No. 319). It was associated with lack of fixation of the colon but with no other variations from the normal.

This condition is rarely observed, perhaps because the possibility is not borne in mind by either the surgeon or the pathologist. Nevertheless Connell [101] was able to collect four cases from the literature, to which he added two of his own. The same is true of excessive rotation, of which no instance was noted in these reports. In both deficient and excessive rotation, when combined with fixation, the ileum can hardly escape being kinked.

VII. VARIATIONS OF DESCENT

The process of descent is late in its completion, starting at about the fifth month and probably not reaching a final adjustment until four months after birth, although at eight months, according to Hertwig [99] and Prenant,[100] the cæcum is usually in what corresponds to the adult position. This is said

detail in the text. It is at once apparent on examination of this table that certain coli are classified as showing both hypofixation and hyperfixation. It is necessary to remember that the term "fixation" is used here to represent what may be termed the embryological process of physiological fusion of the peritoneal layers, which is more properly called zygosis by Keith. So one may find a colon with a mesentery, representing hypofixation and with the peritoneum drawn out into bands or a veil which represents a hyperfixation, that is to say an exaggeration of the process of peritoneal fusion in this particular area. These apparent contradictions will be more fully discussed later. For a full definition of each of these subheadings see the respective sections.

Table of Variations of Descent and Fixation

No.	Sex	Age	Diagnosis	Variation in Descent		Variation in Fixation						
							Hyper-					
				Hypo-	Hyper-	Hypo-	Cystocolic	Hepatic-flexure	Pericolic	Pericæcal	Appendicular	Ileal
212	F	0–9–21	Tuberculous pneumonia. Rhachitis	–	+	+*	–	–	–	–	–	–
214	M	0–3–19	Bronchopneumonia	–	–	–	–	–	–	–	+	–
215	F	0–3–7	Malnutrition. No cause of death found	–	+	–	–	–	–	–	+	–
216	M	0–1–21	Bronchopneumonia. Malnutrition	–	+	–	–	–	–	–	–	–
217	F	1–0–0	Follicular colitis. Rhachitis	–	+	–	–	–	–	–	–	–
220	F	0–0–18	Bronchopneumonia. Malnutrition	–	–	–	–	–	–	–	–	–
223	F	0–1–29	Bronchopneumonia	–	–	–	–	–	–	–	–	+
224	F	0–1–7	Ileocolitis	–	+	–	–	–	–	–	+	+
225	F	0–10–1	Bronchopneumonia. Rhachitis	–	–	–	–	–	+	–	–	–
226	M	.....	"Marasmus"	–	+	–	+	–	–	+*	–	+
227	F	0–1–5	Bronchopneumonia. Malnutrition	–	–	+	–	+	–	–	–	–
229	M	1–3–13	Bronchopneumonia. Adrenal hemorrhage	–	–	–	–	–	–	–	–	–
230	M	.....	.....	–	–	–	–	–	–	–	–	+
231	F	0–1–1	Malnutrition	–	–	+	–	–	+	–	–	–
232	M	1–7–14	Pyæmia. Fracture of mandible	–	–	–	–	–	–	–	–	–
233	M	0–10–28	Bronchopneumonia. Ulcerative enterocolitis	–	–	–	–	–	–	–	–	+
234	F	0–3–11	Malnutrition	–	–	–	–	–	–	–	–	–
239	F	0–8–12	Tuberculous pneumonia	–	–	–	–	–	–	–	–	–
241	F	0–7–10	Bronchopneumonia. Rhachitis	–	+	–	–	+	+*	+	–	–
242	M	1–1–16	Bronchopneumonia. Rhachitis	–	+	–	+	–	–	–	–	–
243	M	0–6–0	Bronchopneumonia. Rhachitis	–	–	–	+	–	–	–	–	–
244	F	0–6–0	.....	–	–	–	–	–	–	–	–	+
245	M	1–0–0–*	Bronchopneumonia. Rhachitis	–	–	–	+	–	–	–	–	–
246	M	0–0–25	"Marasmus"	–	+	–	–	–	–	+	+*	–
247	F	1–6–0*	Bronchopneumonia. Follicular colitis	–	–	–	–	–	–	–	–	–
248	F	0–2–16	Malnutrition	–	–	+	–	–	–	+	–	–
249	M	0–4–21	Generalized miliary tuberculosis	–	–	–	–	–	–	–	+	–
250	F	0–7–25	No cause of death found	–	–	–	–	–	–	–	–	–
251	M	0–3–0	"Marasmus"	–	–	–	–	–	–	–	–	–
252	F	0–0–21	"Marasmus"	–	–	–	–	–	–	–	–	–

| | | |

TABLE OF VARIATIONS OF DESCENT AND FIXATION—*Continued*

No.	Sex	Age	Diagnosis	Variation in Descent: Hypo-	Descent: Hyper-	Fixation: Hypo-	Fixation: Hyper- Cystocolic	Hepatic-flexure	Pericolic	Pericæcal	Appendicular	Ileal
308	F	0–1–15	Bronchopneumonia. Congenital syphilis	–	–	–	+	–	–	–	–	–
309	M	0–0–20	Malnutrition	–	–	–	–	–	–	–	–	+
312	M	0–1–6	No cause of death found	–	–	–	+	–	–	–	–	–
314	F	0–1–16	No cause of death found	–	–	–	–	–	–	–	–	–
315	M	0–0–26	No cause of death found	–	–	–	–	–	–	+*	–	–
316	M	0–8–8	Bronchopneumonia	+	–	–	+	–	–	–	+	–
319	F	0–1–0*	No cause of death found	–	–	+	–	–	–	–	–	–
321	M	0–6–0	Bronchopneumonia	–	+	–	–	–	–	–	–	–
322	F	0–3–27	Bronchopneumonia	–	+	+	–	–	–	–	–	–
323	F	1–6–0*	Bronchopneumonia. Rhachitis	—	+	–	+	+	+	–	–	–
324	F	0–2–17	Malnutrition	–	–	–	–	–	–	–	–	–
325	F	0–1–15	No cause of death found	–	+	–	–	–	–	+	–	–
329	F	0–10–27	Abscess of lung	–	–	–	–	–	–	–	–	–
330	M	0–2–4	Subperiosteal abscess of mandible	–	–	–	–	–	–	–	–	–
331	M	0–0–14	Subdural hemorrhage	–	–	–	–	–	–	–	–	–
332	M	0–0–19	Bronchopneumonia	–	+	+	–	–	–	–	–	–
333	F	0–2–0*	No cause of death found	–	–	–	–	–	–	–	–	–
334	F	0–6–0	Bronchopneumonia	–	+	–	–	–	–	–	–	–
336	M	0–3–0	No cause of death found	–	–	–	–	–	+	–	–	–
337	M	0–2–24	Bronchopneumonia	–	–	–	+	–	–	–	–	–
343	F	0–4–13	Rhachitis	–	+	+	+	–	–	–	–	–
345	M	0–9–8	Bronchopneumonia	–	–	–	+	+*	–	–	–	–
348	F	0–3–3	Malnutrition	–	–	–	+	–	–	–	–	–
349	M	0–2–0	Bronchopneumonia. Rhachitis	–	–	–	–	–	–	–	–	–
351	M	0–5–3	Bronchopneumonia. Rhachitis	–	–	–	–	–	–	–	–	–
352	F	0–5–18	Bronchopneumonia	–	–	–	–	–	–	–	–	–
356	M	0–3–0	Malnutrition	–	–	–	+	–	–	–	–	–
357	F	0–6–0	Bronchopneumonia. Peribronchial abscesses	–	–	+	–	–	–	–	–	–
360	M	0–3–0	Purulent bronchitis	–	+	–	–	+*	+*	+	–	–
361	F	0–6–0*	Congenital syphilis	–	–	–	–	–	+*	–	–	–
			Total 105	1	22	14	20	10	17	13	8	9

to be " in the right iliac fossa resting on the iliac fascia covering the iliopsoas muscle above the outer part of Poupart's ligament about half below and half above the level of the anterior iliac spine " (Piersol [102]). If one takes this description literally the variations outnumber the normal. Such minor variations, however, are of no importance either anatomically or surgically, and it is only the marked variations that have been noted in these examinations.

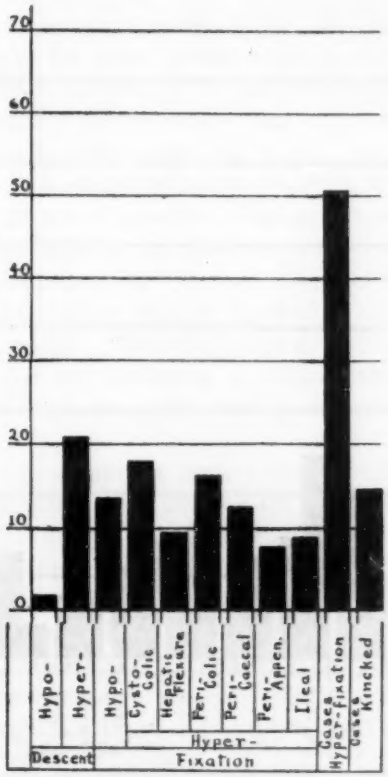

FIG. 5.—Incidence of peritoneal variations in 105 infants shown by percentage.

There are again two possible types of variations from the normal, namely, (*a*) deficient descent (hypodescent), and (*b*) excessive descent (hyperdescent), under which titles these will be discussed.

(*a*) *Hypodescent.*—This term should cover instances in which the cæcum lies anywhere between the region of the liver and its normal position, but in this group of cases this condition was noted only when the cæcum had failed to descend at all; that is to say when it continued to lie in the right hypochondrium. Only two such instances were observed and these are too few to draw any definite conclusions as to its association with other variations.

Smith,[103] in his series of 1050 autopsies on infants, found 63, or 6 per cent., in which the cæcum lay between the liver and the right iliac crest.

Using much the same standard, Byron Robinson [82] reported 25, or 8 per cent., in 310 males, and 5, or 4 per cent., in 125 females, or about 7 per cent. in all the cases. Treves [21] reported the undescended cæcum in 2 per cent. of his observations, this meaning in all probability that the cæcum lay just beneath the liver. Alglave [104] in 100 subjects, of which 50 were male and 50 female, found the ileocæcal segment in the lumbar situation in 3 per cent. It can be concluded, then, that in about 2 per cent. of all cases the

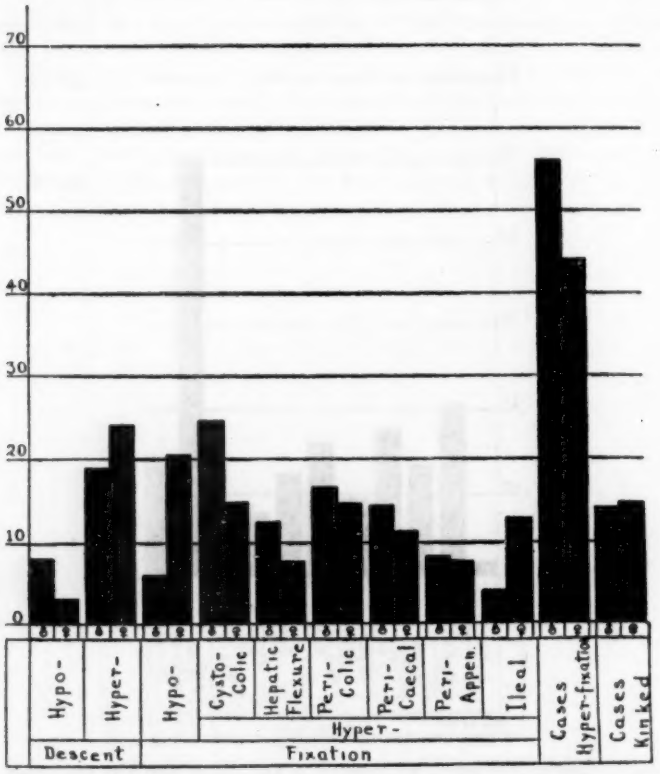

FIG. 6.—Incidence of peritoneal variations in 105 infants according to sex shown by percentage. ♂ = male; ♀ = female.

cæcum may be found in the right hypochondrium and in about 6 per cent. lying between there and its normal position in the right iliac fossa.

(*b*) *Hyperdescent.*—The cæcum may continue in its descent passing from its normal position, as defined above, into the pelvis, or develop such length and freedom of movement that it is possible for it to lie in the pelvis. Such instances were noted as cases of hyperdescent, and in the 105 examinations this condition was found in 22, or in about 21 per cent. (Fig. 5), of which 8 were in males and 13 in females (Fig. 6).

The following table shows the frequency of this variation as found by various observers:

Name.	No. of cases.	Per cent.	†Per cent.	‡Per cent.	Remarks.
Engel [11]	100	8	..	..	Necropsy
Lockwood [20]	200	18	..	..	At operation
Robinson [23]	435	13	10	20	Necropsy
Smith [108]	1050	10	..	..	Necropsy (infants)
Tuffier and Jeanne [108]	..	16	..	..	Necropsy
Alglave [104]	100	23	17	30	Necropsy
Harvey	105	21	18	24	Necropsy (infants)

It is of interest to ascertain whether the frequency of hyperdescent increases or decreases as the infant grows older, as in this way we can arrive at some idea as to when the cæcum reaches its adult position and relations. This is done by dividing the necropsies into three age periods and determining the frequency in each period [f] (Fig. 7). By reference to this table it is seen that there is a quite remarkable increase in the frequency of this condition for the first 3 to 6 months. This agrees with the observation of Treves that the large intestine increases rapidly in length during the first few months of extra-uterine life. It may be argued that with the lengthening of the body and the other changes incident to maturity the cæcum may resume its normal position. That this is not so is shown by reference to the statistics of Lockwood and Robinson in adults quoted above, which agree so closely with ours that one must conclude that there is retrogression of this process.

Hyperdescended cæca may be divided into two groups, depending upon whether the colon is attached to the parietal wall (normal fixation) or has a mesentery (hypofixation). Of the former there are 17, or 77 per cent., of the cases of hyperdescent, the remainder, or 23 per cent., being associated with hypofixation of the colon (Fig. 8). This is of considerable interest, inasmuch as it is frequently assumed that a cæcum lying in the pelvis is evidence of ptosis of the viscera, while the above demonstrates that something over three-fourths have their normal support from the attachment of the colon to the abdominal wall and are examples of a true overgrowth. As further evidence of this the fact may be noted that practically none of the infants here cited lived to assume the erect posture. This being so, it is probable that many instances of hyperdescent combined with hypofixation of the colon are as well instances of overgrowth.

It is of interest to ascertain if there is any correlation between hyperdescent and the formation of the various membranes classified under hyperfixation. Such a comparison indicates that hyperdescent does not involve any marked increase or decrease in the presence of accompanying membranes or bands about the colon.

It was not responsible in itself for any kink or angulation of the gut.

[f] It is realized that the limited number of cases examined renders the data and conclusions derived therefrom by no means accurate. It seemed advisable, however, to attempt an analysis, inasmuch as the results obtained, if not entirely conclusive, are highly suggestive.

VIII. VARIATIONS OF FIXATION

The process of fixation of the large intestine is that of a "physiological fusion" of contiguous peritoneal surfaces, technically known as zygosis (Keith). A deficiency of this process may be termed azygosis or hypofixation, and one of the results of this deficiency is the presence of a mesentery of the ascending colon. When very marked, this results in the well-known mesenterium commune. An excess of fixation may be termed hyperfixation, and consists of the fusing together of peritoneal surfaces

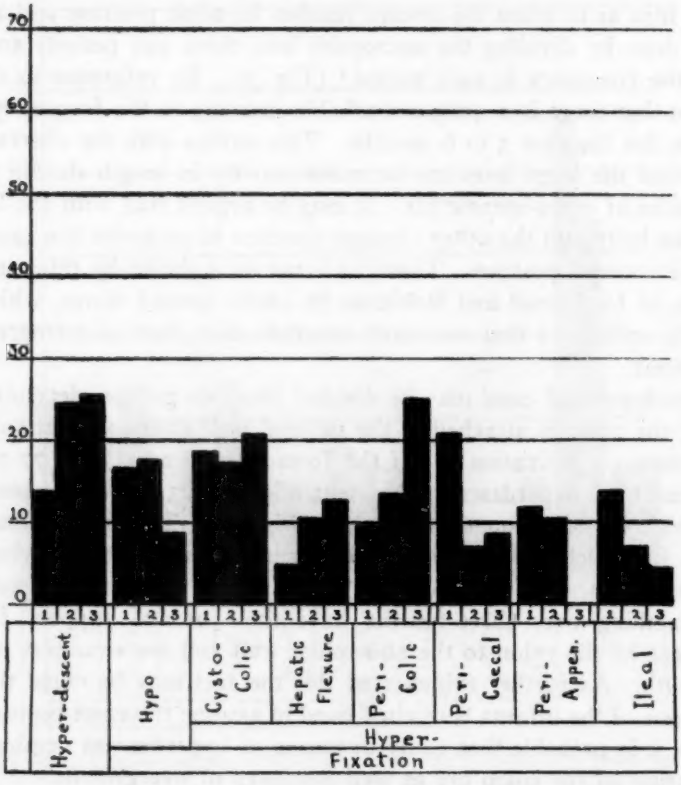

FIG. 7.—Incidence of peritoneal variations in 105 infants according to age shown by percentage. Group I = first two months of extra-uterine life; group II = third, fourth and fifth months of extra-uterine life; group III = the remaining necropsies falling between six months and eighteen months, one being three years and seven months of age.

normally separated. This latter may take place along the entire course of the ascending colon or, as is the case more frequently, at certain portions of it, and does not in this discussion necessarily mean adhesions from the gut to the parietal wall, but includes those stretching between adjacent loops of the intestine, and even the thickened and striated appearance of the peritoneum, so frequently seen covering the mesentery of the ascending colon. These last structures represent an excessive peritoneal fusion, relative to the freedom allowed by the mesentery, and a consequent thickening as a result

of the uneven strain thrown upon the peritoneum during the further developmental changes (Riedel, Lane, etc.).

(*a*) *Hypofixation.*—Since the early anatomists a mesocolon on the right has been recognized many times, and following Treves' studies it has become a matter of common knowledge that a mesocolon may be frequently found on either the ascending or the descending coli. The following table gives the

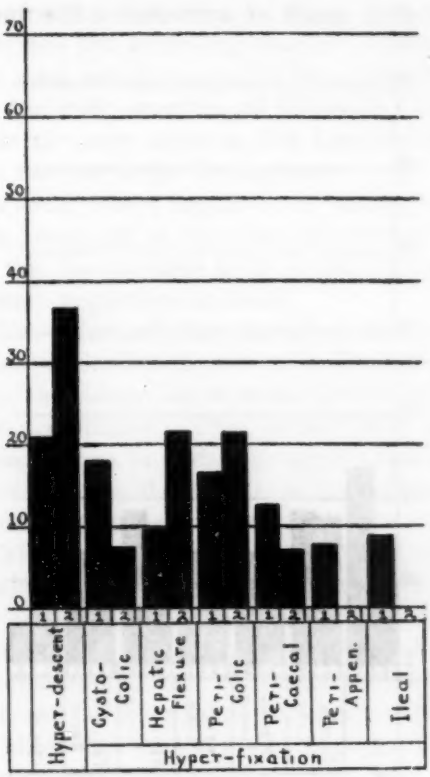

FIG. 8.—Incidence of peritoneal variations in the entire series (1) and in hypofixation (2), compared by percentage.

frequency of a mesentery on the right side as determined by several investigators:

Name.	No. of cases	Per cent
Treves [28]	100	26
Addison [21]	40	15
Smith [103]	982	31
Fallon [106]	100	24
Piersol [103]	35	14
Dreicka [107]	640	23

In this study, under the term "hypofixation," those instances were included in which there was a mesentery of at least the lower two-thirds of the

descending colon. In the 105 necropsies a mesocolon on the right side was found in 14, or in 13 per cent. (Fig. 5). Of these 3, or 6 per cent., were in males and 11, or 20.4 per cent., in females (Fig. 6). This seems to indicate a later fixation of the intestine in the female than in the male, and corresponds with the observations of Klose[43] and Wilms[58] as regards the greater frequency of the "cæcum mobile" in the female.

As regards the time of cessation of fixation, reference to Fig. 7 indicates that even after the sixth month of intra-uterine life this process is still in

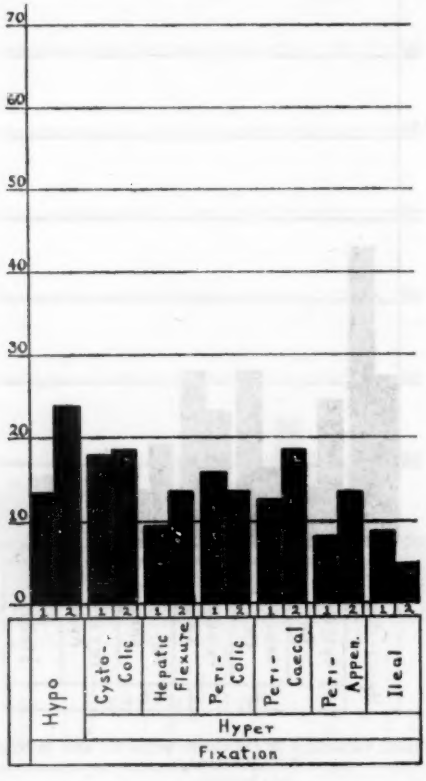

FIG. 9.—Incidence of peritoneal variations in the entire series (1) and in hyperdescent (2) compared by percentage.

progress; it is then a somewhat later process than the descent of the cæcum, which reaches a state of equilibrium about the third month, according to the same table.

The relative infrequency of hypofixation in the cases of hyperdescent has shown that this latter condition is probably an overgrowth of the colon. However, the frequency of hyperdescent in the 105 necropsies is 21 per cent. and in the instances of hypofixation it is 36 per cent. (Fig. 8). This represents a very definite increase which may mean either that the intestine, because of its loose attachment, has slid down into the pelvis, which seems improbable from the previous argument, or that the process of fixation,

which has been completed early, may exert a restraining influence upon the further descent of the colon.

The relative increase or decrease in frequency of the membranes of hyperfixation in these cases with a mesentery of the ascending colon, as compared with the frequency in the entire series, is shown in Fig. 8. It may be noted by reference to this that membranes about the gall-bladder (cystocolic membranes) are relatively infrequent, as are also membranes and bands about the cæcum, appendix and ileum. On the contrary, those about the hepatic flexure and ascending colon are relatively increased. As will be shown later, these membranes are in large part the result of incomplete involution of the colic omentum of Haller and so represent incomplete development in the same sense as does hypofixation. Hence such a correlation between the two might be expected.

Hypofixation, in itself, caused angulation or kinking of the gut but once. In this instance the lower end of the colon was turned upward anteriorly and to the left, so that the tip came to lie in the region of the umbilicus, thus producing a sharp angulation on itself.

(*b*) *Hyperfixation.*—Normally the ascending colon, with the exception of two or three inches proximal to the cæcum, is attached to the areolar tissue in the flank and over the kidney, but at certain points the lines of peritoneal attachment may be accentuated. Thus at the lower end are found the parietocolic and mesentericocolic folds, improperly called the Jonnesco's ligaments; at the hepatic flexure, the right renocolic ligament of Haller; and at the transverse portion of the colon the "cystocolic fold" or ligament of Huschke. These folds are many times absent, and, indeed, it is difficult to establish a normal standard for any of these structures, but in as far as it is possible this will be attempted under the separate heading given below.

The subdivisions adopted in this discussion do not imply that the structures described are but modifications of the anatomical structures normally found in these positions, but are used as convenient topographical divisions of the membranes about this portion of the large intestine.

1. Cystocolic hyperfixation.
2. Hepatic flexure hyperfixation.
3. Pericolic hyperfixation.
4. Pericæcal hyperfixation.
5. Periappendicular hyperfixation.
6. Peri-ileal hyperfixation.

1. *Cystocolic Hyperfixation.*—The lesser omentum is described as extending from "between the transverse fissure of the liver on the right side of the abdominal portion of the œsophagus to the lesser curvature of the stomach and the upper portion of the anterior surface of the duodenum" (Piersol [102]). The portion included between the liver, the œsophagus and the stomach is called the "hepatogastric ligament," and that between the liver and the duodenum the "hepatoduodenal ligament." The free portion of the omentum ends above with the passing of the upper attachment out

upon the posterior surface of the gall-bladder, and below with its continuation over the descending portion of the duodenum as far as the transverse colon. This, then, comprises the hepatocolic ligament or cystocolic fold to which adequate attention was first attracted by Huschke, and which is sometimes termed the ligament of Huschke.

The cystocolic fold has been discussed by several writers, and the following table gives the frequency of occurrence as so determined:

Name	No. examined	Per cent.
Jonnesco [22]	100	25
Addison [21]	40	30
Mollison and Cameron [109]	50	20
Buy [109]	..	25
Bricon [110]	89	15
Reid [84]	20	30
Leveuf [96]	50	28
Ssulow [111]	145	23
Harvey	105	18

Six of Mollison's and Cameron's cases were in fœtuses and seventeen under five years of age, Reid's cases were all in fœtuses, and Leveuf's in infants autopsied directly or shortly after birth. Brewer [112] in addition reports 3 per cent. of 100 cases in which the cystocolic fold extended over the fundus of the gall-bladder. Ancel and Sencert,[113] as well as Rubin,[114] have in recent years noted this condition in the new-born.

In the present series only those cases were recorded as hyperfixation in which the fold extended upon the gall-bladder over a third of the length of this viscus, this being used as a convenient measure of its overdevelopment. In the 105 cases autopsied, 20 instances were noted falling within this definition, or about 18 per cent. (Fig. 5). These varied from simple folds, extending upon the gall-bladder an inordinate distance, to peritoneal bands and membranes spreading entirely over the fundus and outward upon the surface of the liver, with exactly the appearance seen several times during laparotomies in the adult and interpreted by the operator as indicative of chronic inflammation of the gall-bladder. In such instances the gall-bladder and intestine may be almost approximated by this hyperfixation, which may also serve to angulate the duodenum or transverse colon or both, producing on röntgen study the appearance of stasis and thus simulating duodenal ulcer (Harris [132] and Homans [133]).

Of these 20 variations, 12 were in males and 8 in females, or 25 per cent. and 15 per cent. respectively. As may be noted by reference to Fig. 6, this slight preponderance of the male in variations of hyperfixation holds true throughout except for ileal hyperfixation. The correlation of this with a like preponderance in hypodescent suggests that this represents an earlier maturity of the male.

The development of the cystocolic fold apparently reaches a stable condition sometime previous to birth, the three arbitrary periods shown in

Fig. 7 having nearly the same percentage of incidence. Consequently one would not expect any correlation between the occurrence of this fold and the other variations which are to a great extent in a period of transition at the time of birth.

Reference to Fig. 10 shows the relative frequency of occurrence of the cystocolic fold in the entire series of cases and in the different variations under discussion. It will be noted that there are no definite differences,

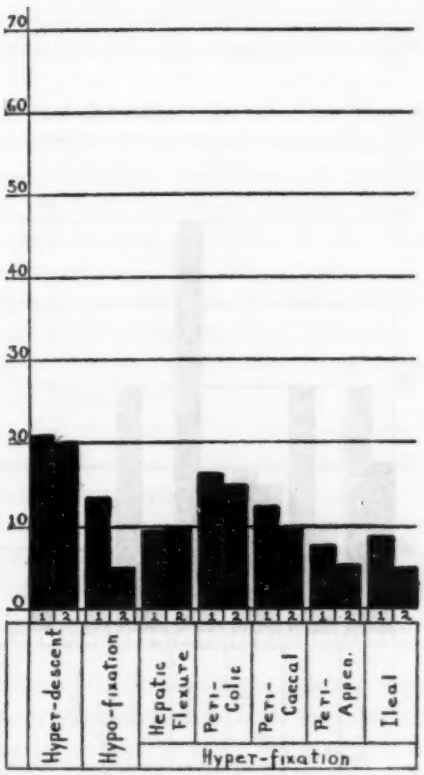

FIG. 10.—Incidence of peritoneal variations in the entire series (1) and in cystocolic hyperfixation (2) compared by percentage.

with the exception of that shown under the heading of hypofixation, where the cystocolic fold is, of course, present relatively infrequently.

There was no case observed in which the overgrowth of this structure led to kinking or serious angulation of the gut, although the possibility of this on further increase in size of the intestine was apparent. It seems very probable that such hyperfixation may at times produce stasis within the gall-bladder, but this point was not determined.

2. *Hepatic Flexure Hyperfixation.*—Fixation of the colon in the neighborhood of the right kidney is so closely correlated with the development of the great omentum that it is necessary to consider the embryonic status

of the latter. As Toldt,[5] Prenant,[100] and Leveuf [96] have pointed out, the omentum at about the sixth month of fœtal life in man and also in the other primates may extend as far downward as the cæcum. In man it diminishes in extent as the fœtus matures until it reaches only as far as the hepatic flexure, but in the higher monkeys it persists in its fœtal condition.

One may consider, then, the normal extent of the omentum on the right as reaching as far as the hepatic flexure. It becomes there continuous by its

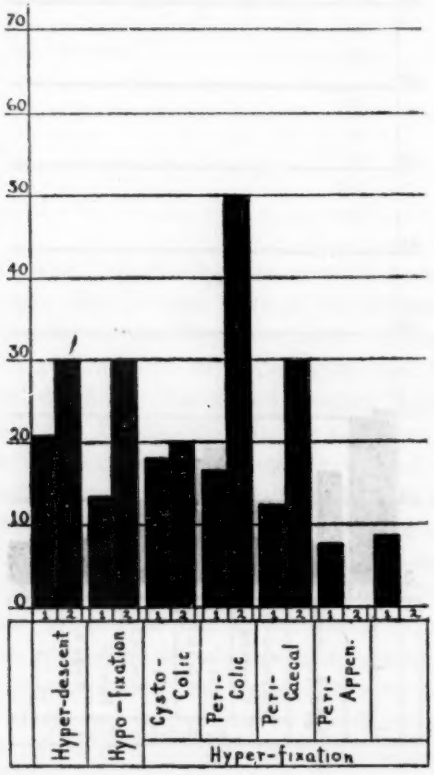

FIG. 11.—Incidence of peritoneal variations in the entire series (1) and in hepatic flexure hyperfixation (2) compared by percentage.

anterior layer with the peritoneum over the duodenum and the upper pole of the right kidney. A similar process on the left serves to form the ligamentum pleurico-colicum and in certain instances the adhesions and bands about the splenic flexure to which Payr [41] has called attention. If the process of fusion proceeds farther than usual, the omentum may be directly continuous with the parietal wall, and where persistent over the ascending colon may also be continuous with the parietal peritoneum, as Leveuf [96] has pointed out, producing pericolic hyperfixation. Also the persistence of the colic omentum of Haller may result, by a failure on its part to grow as rapidly as the colon itself, in a relative shortening of the omentum as it stretches

across the colon, producing angulation and kinking in the latter or at least producing bands and membranes having quite the appearance which we have come to associate with peritoneal inflammation. In a third variety the omentum stretches across the angle of the junction of the ascending and transverse coli and in exaggerated instances forms the so-called "double-barrelled" colon.

In the examination of 50 infants at or shortly after birth Leveuf [96] found 10, or 38 per cent., with a prolongation of the omentum upon the ascending coli beyond what he considered normal for the adult. It is his opinion that the persistence of this structure accounts for the so-called "Jackson's veil."

In the instances under discussion hepatic hyperfixation includes omenti which descended more than 2 cm. upon the ascending colon as well as other membranes and band-like structures in this region. Using this standard in 105 cases, Haller's omentum was present nine times and membranes about the hepatic flexure, probably of this origin, once, giving a total of ten omental membranes, or of 9.5 per cent. (Fig. 5.) These structures are slightly more prevalent in the male (Fig. 6), being associated with cystocolic hyperfixation in this respect. There is a slight increase as the infant grows older (Fig. 7), and in this it is correlated with a similar increase in the pericolic hyperfixation.

An inspection of Fig. 11 shows the quite marked association of this variation with hyperdescent and still more strikingly with hypofixation. It was suggested previously that hyperdescent may be due in part to a lack of normal fixation with its restraining effect on the growth of the intestine. The correlation between the persistence of the fœtal type of colic omentum and hyperdescent would seem to confirm this. Hypofixation and the colic omentum naturally go hand in hand inasmuch as both are deficiencies of development.

A further inspection of this table shows that about 50 per cent. of these persisting omenta occur in conjunction with pericolic hyperfixation and 30 per cent. with pericæcal hyperfixation. This serves to support Leveuf's view that adhesions about the colon and cæcum are the result of the persistence of the fœtal type of omentum in a large number of cases, but, on the other hand, quite as clearly demonstrates that this hypothesis does not cover all instances of such adhesions. The other factors responsible will be discussed under the appropriate headings.

It is also of interest to note that none of these omental membranes are associated with periappendiceal or ileal hyperfixation, which should serve to discourage the extension of Leveuf's hypothesis to this portion of the intestine.

In two instances the presence of the colic omentum caused definite angulation or kinking of the large intestine.

3. *Pericolic Hyperfixation.*—The colon on the right side in adult life is usually attached over the upper two-thirds of the ascending portion and

over about one-third of its circumference to the areolar tissue over the posterior abdominal wall and the right kidney, the lower third merging with the cæcum and, like it, being covered with peritoneum. As the peritoneum leaves the colon on its posterior surface and turns downward toward the pelvis it is reflected laterally in two folds, the parietocolic and the mesentericocolic.

The colon continues to increase in length up to the third month after birth, while the process of fixation is going on over the same time, but lasting somewhat longer; that is, up to the sixth or seventh month after birth. There is then obviously a certain relationship between these two processes, which is essential to the normal fixation and descent of the gut. Certain aberrations in this relationship have been suggested as the cause of "Jackson's veil" (pericolic hyperfixation). C. H. Mayo [79] states that the colon prematurely fixed continues to grow and thus appears to burrow under the peritoneum, dragging it downward in the slanting membranous folds seen in this condition. Flint [81] suggests that such membranes represent successive secondary fusing of the parietal, colic and omental peritoneum which have been drawn downward by the continued descent of the cæcum. Leveuf,[96] as noted previously, refers these bands and membranes to a persisting and adherent colic omentum. Many writers, and especially Riedel and Lane, have called attention to the thickening of the mesentery of an unattached colon so that it seems to be made up of several suspensory bands.

The term pericolic hyperfixation may then refer to and include several different variations, all of which, however, come under the definition of a fusing together of peritoneal surfaces normally separate. The structures in this series varied from film-like prolongations of the peritoneum, scarcely to be observed until the intestine was distended, to distinctly thickened and strong bands of peritoneum causing acute angulation of the gut. In some instances these were very apparently remnants of the fœtal colic omentum, in others these were portions of the parietal peritoneum which had become adherent over some small area to a greater extent than elsewhere, or over the greater length of the ascending colon so that when the latter became distended the peritoneum was stretched out in the form of a membrane. In still others a premature fixation with continued growth of the intestine had produced much the same effect, and here the membrane might be drawn into folds like those in a drooping pennant or the colon held as if in a "diaphanous bag" (Jackson [86]).

Though one recognizes in the description of Virchow [14] and many others of the early writers the characteristics of the membranes about the ascending colon, there is but little data at hand as to their frequency. Morley [90] examined 36 fœtuses and found a "Jackson's membrane" in 4, while Eastman [77] in 28 found in 5 the same structure, which he termed the parietocolic fold. Cheever [88] in 30 stillborn infants found this form of hyperfixation 4 times, but Eisendrath and Schnoor [95] state that in 10 fœtuses each showed some form of what Eastman terms the parietocolic membrane. Blake [115]

has even gone so far as to state that Jackson's membrane is a perfectly normal structure always present.

In the series of 105 infants here reported, pericolic hyperfixation was observed some 17 times, or in something over 16 per cent. (Fig. 5).

It occurred with about the same frequency in both sexes (Fig. 6).

According to the three arbitrary age periods previously described, there is a quite marked increase in frequency during the first year of life; namely from about 9 per cent. during the first two months to about 25 per cent.

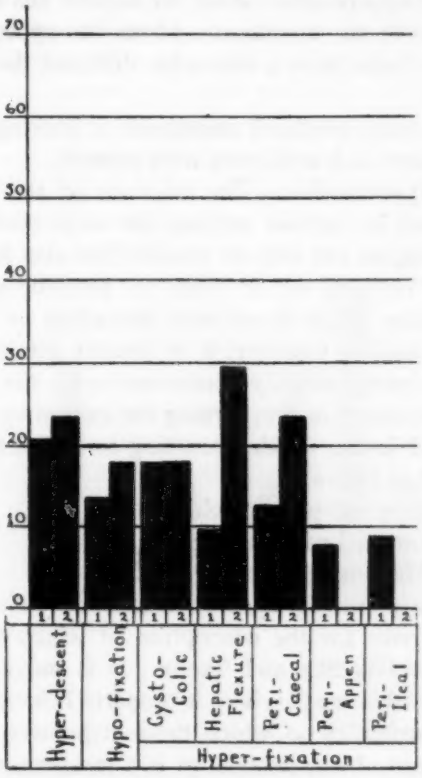

FIG. 12.—Incidence of peritoneal variations in the entire series (1) and in pericolic hyperfixation (2) compared by percentage.

after seven months of age (Fig. 7). This illustrates again the relative tardiness of completion of descent and fixation and might be taken as evidence for the theory of inflammatory origin were it not, as will be shown later, that the pericæcal, periappendicular and peri-ileal hyperfixation decreases over this same period. It also shows rather conclusively that only a minority, at most, of these pericolic membranes can be persisting colic omentum of Haller, inasmuch as the tendency in the latter is toward retrogression.

An inspection of Fig. 12, indicating the relative frequency of occurrence of the various variations under discussion in the entire series and in the

cases of pericolic hyperfixation, shows the following: Hypofixation is present in about 4 per cent. more of these cases, a difference hardly above the limit of error. There is no greater frequency of hyperdescent or of the cystocolic folds. Membranes about the hepatic flexure, however, are present about three times as frequently in association with this group as in the complete list, and pericæcal hyperfixation twice as frequently. This group, then, stands closely related to the lesions on either side, a greater number, however, being of the same derivation as the omental. As in the preceding group of hyperfixation about the hepatic flexure, there is no association whatever with the membranes about the appendix and the ileum, suggesting that the latter have a somewhat different derivation than any so far discussed.

Pericolic membranes produced angulation or kinking of the gut twice in the 17 instances where such structures were present.

4. *Pericæcal Hyperfixation.*—The relations of the cæcum to the peritoneum as described by various authors are most confusing, inasmuch as they frequently disagree not only in content, but also in nomenclature.

The cæcum is invested on all sides by peritoneum and in the great majority of instances, all but 6 per cent. according to Berry,[25] there is no mesentery. Occasionally, however, it is directly attached to the posterior wall or has a mesentery directly continuous with the mesocolon. In the typical specimen examined *in situ*, turning the cæcum upward reveals certain peritoneal folds and fossæ, which, according to Berry, may be named from the right to the left as follows:

External-parieto-colic fold.
Internal-parieto-colic fold.
Mesenterico-parietal fold.

These are the structures frequently spoken of as the folds or ligaments of Jonnesco, the credit for the description of which should, however, be distributed between Huschke and Treitz. It is only fair to Jonnesco to state that he assigns this credit where it properly belongs.

The extreme variability to which these structures are subject and of which the uncertainty of our knowledge is a measure, renders it somewhat questionable as to whether they are worthy of the dignity of as extensive a nomenclature as has been assigned them. For the purpose of simplicity they will be spoken of in this paper as the subcæcal folds.

It has been assumed by some that the purpose of these folds is to serve as guys to anchor the cæcum or rather the lower end of the colon in place, and that they undergo a very purposeful anatomical development. Treitz,[16] Gruber,[20] and more recently Lockwood and Rolleston[29] state that the cæcum is dragged downward by the gubernaculum through the medium of the mesorchium or mesovarium, the peritoneum following unequally, thus producing the folds and fossæ. Waldeyer[19] rejected this theory and suggested that the development of the cæcum after fixation of the colon was responsible for such plication of the peritoneum. Jonnesco,[22] and more

recently Berry,[25] thought that the delayed and secondary fixation of the ascending colon as described by Toldt [5] would more reasonably account for such folds. These theories are especially interesting as unrecognized progenitors of hypotheses advanced very recently in respect to the formation of Jackson's membrane, Lane's band, etc.

In the examination of the subjects reported in this paper these subcæcal folds were regarded as normal structures and, consequently, were not recorded, although possibly having the same derivation as the pericæcal mem-

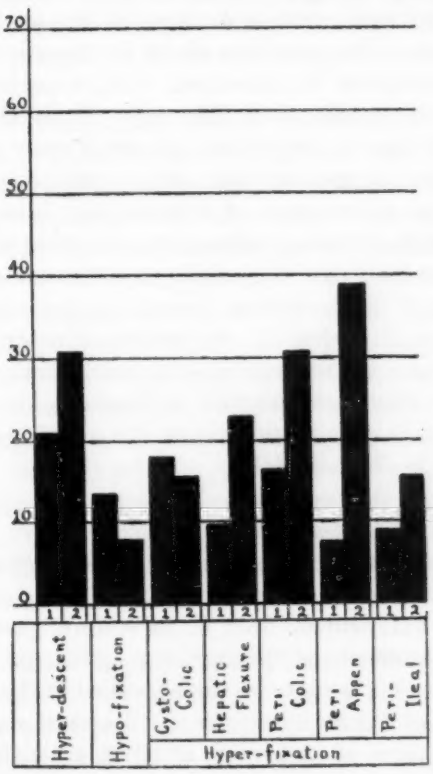

FIG. 13.—Incidence of peritoneal variations in the entire series (1) and in pericæcal hyperfixation (2) compared by percentage.

branes. The latter were in general of two types, those extending from the parietal wall to the cæcum and those extending only over the surface of the cæcum. Both were frequently continuous with membranes of a similar nature covering the colon. In the former the peritoneum frequently extended in a fan-shaped manner from the parietes downward over the cæcum, in exaggerated instances giving the appearance of a sling. At other times a definite fold was produced which could easily be imagined as serving a suspensory function. Lastly and rarely the cæcum itself was partially attached to the parietal wall by a mesentery. In the case of the membranes

confined to the cæcum itself the appearance was that seen in the omental membranes above, where the embryonic omentum had not undergone involution, and fine bands and thinly spread peritoneum stretched across furrows in the gut.

Such membranes were present in 13 of the 105 cases examined, being very slightly more prevalent in the male (Figs. 5 and 6).

They were much more frequent in the first of the arbitrary age periods (Fig. 12), corresponding in this respect with the periappendicular and perileal hyperfixation, suggesting, as will be discussed later, that the membranes about the cæcum and ileum tend to decrease in frequency with the increase in age, the converse of the condition about the hepatic flexure.

Pericæcal hyperfixation is associated with hyperdescent much more frequently than with hypofixation (Fig. 13). It is also coincident with many pericolic and hepatic membranes but much more so with periappendicular hyperfixation, suggesting that only a relatively small number of pericæcal membranes are a result of deficient involution of the omentum. Six or nearly one-half of these produced some kinking or angulation of the cæcum, but for the most part this consisted of an increase, very distinct, however, in the depth of the normal furrowing, and represented an exaggeration of the normal folding of the cæcum as described by Toldt.

5. *Periappendicular Hyperfixation.*—In close relation to the appendix there are normally three quite distinct peritoneal folds which are named, according to Berry's [25] classification, from above downward as follows:

The ileocolic fold.
The ileocæcal fold.
The meso-appendix.

The ileocolic fold was first described by Luschka [17] and more in detail at a later date by Jonnesco,[22] who defined it as " . . . un repli péritonéal qui part du feuillet antérieur ou droit du mésentère, passe pardessus ou en avant de la portion terminale de l'iléon pour se perdre sur le cæcum."

The ileocæcal fold or, as more commonly called in the English literature, the " bloodless fold of Treves," occupies the ileocæcal angle in front of the mesoappendix with three of its borders attached, extending from the ileum downward upon the cæcum.

It is very difficult to gain from the literature a definite idea of the frequency of the variations in the meso-appendix; Berry [25] states that it may be termed normal in about 75 per cent., but these as well as Treves' figures are based upon variations in the position of the meso-appendix rather than upon variations in which it assumes the appearance of an adhesion. In Treves' sixth position he states that " the appendix has no mesentery at all, but is adherent in a vertical line to the posterior wall of the cæcum, its extremity being, as a rule, however, free." In this position Berry found 3 per cent. of the cases examined by him. He states, further, that " if the writer's views as to the etiology of appendicitis be accepted, it follows that about 6 per cent. of the populace have appendices so situated as to predispose them

to appendicitis." Ferguson [116] in his 200 cases found in 77 the appendix so placed and covered by peritoneum that its perforation would open into the subperitoneal tissue. Lockwood and Rolleston [29] in 160 examinations found the appendix adherent in 33. Mollison and Cameron [108] describe, in an investigation of 35 autopsies, adhesions about the appendix, in three of which there was no evidence of peritoneal inflammation. Leveuf [96] examined some 50 fœtuses and in 16 per cent. of these found peri-appendicular adhesions. Albrecht [117] in 500 children, the oldest being 6 years of age, found 15 per cent. with anomalous positions produced by adhesions. Many other writers have called attention to the presence of congenital adhesions about the appendix, but extensive data as to the frequency of such abnormalities are not at hand.

Only the extreme instances of unusual attachment of the appendix were noted in this series, and these would for the most part fall in the very late variations of the meso-appendix as classified by Treves. The most striking form was where the appendix was held posterior to the cæcum in the retrocolic fossa by an adhesion sometimes near the base but frequently extending nearly to the tip, which was usually free. The appendix gave the appearance of having been relatively prematurely fixed and with the descent of the cæcum of being turned upward and backward upon itself. In all, 8 instances (Fig. 5) of hyperfixation were observed in this series of 105 cases and (Fig. 6) these were distributed evenly between the male and the female.

The incidence according to the arbitrary age periods (Fig. 7) is about the same in the second and the first periods but nil in the third. This suggests that there may be a certain amount of involution involved in the formation of the peritoneal attachments of the appendix, somewhat analogous to that observed in the development of the colic omentum of Haller, but the number of cases observed is too few to arrive at any definite conclusion on this point.

Such periappendicular hyperfixation is more frequently associated with pericæcal and peri-ileal hyperfixation (Fig. 14) and not at all with that observed about the colon and hepatic flexure, indicating that the latter are not of an analogous derivation.

Kinking of the appendix in connection with these variations was observed twice.

6. *Peri-ileal Hyperfixation.*—The ileum is normally free throughout, having the shortest portion of its mesentery at the ileocæcal junction. Usually the ventral layer of the mesentery is continuous to the right with the peritoneum covering the anterior surface of the ascending colon and cæcum while the dorsal layer turns backward and to the left to cover the posterior parietal wall. At the junction of the cæcum and the ileum this posterior layer forms a fold leading downward toward the iliac fossa, the mesentericoparietal fold of Jonnesco and Berry, first described by Huschke [12] and discussed above under the heading of Pericæcal Hyperfixation. This should not be confused with the structure now known as Lane's band.

Normally, as stated previously, the ventral sheet of the mesentery of the ileum does not fuse with the posterior parietal peritoneum, but, as was pointed out by Toldt,[5] writing in 1879, this occasionally occurs so that the terminal ileum is fixed to the posterior parietal wall in the same manner as the ascending colon. Treves [21] wrote in 1885 that " in not a few specimens the terminal part of the small intestine has been closely attached to the psoas muscle, not by direct adhesion, but by means of a fold of peritoneum that has passed from the or under the layer of the mesentery to the serous

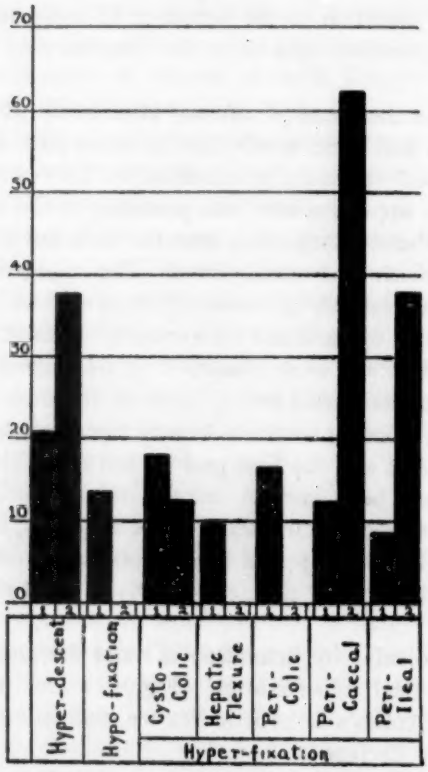

FIG. 14.—Incidence of peritoneal variations in the entire series (1) and in periappendicular hyperfixation (2) compared by percentage.

membrane covering that muscle." Addison,[31] in 1900, described such conditions in detail and distinctly called attention to the presence of adhesions at this point which have since become known as Lane's bands. To quote Addison: " This portion of the lower end of the ileum is often made firmer by a prominent peritoneal fold passing downwards from beneath the ileum, near where it overlies the inner border of the psoas, to Poupart's ligament. . . . With a shorter peritoneum the movements of this part of the ileum become more limited. Sometimes it is bound down completely to the iliac fossa, while in other cases it lies in the pelvic cavity with a prolapsed cæcum."

Recently Reid [84] has described this condition anew, associating with it, as did Addison, a vestigial fold resulting from the descent of the ovary or testicle, and has given it the name of the genito-mesenteric fold. This association is far from original, being first proposed by Treitz,[16] in 1857, who supposed that the mesenterico-parietal fold was formed by a union of the mesorchium with the serous coat of the cæcum and that the descent of the orchis drew out the peritoneum into a fold which he named the "plica genito-enterica." This theory was rejected by Waldeyer [19] and Jonnesco,[22] the latter basing his opinion on not finding any such association embryonically, and on Toldt's [5] researches which showed the secondary fusion of the colon at a late period in fœtal life.

The presence of a vestigial fold, in many cases, in the peritoneum lining the posterior parietal wall in this particular region can not be doubted, and such a genital fold has long been recognized by anatomists, being constantly seen in the young embryo.

The Wolffiam body, or mesonephros, is enclosed and attached to the posterior body wall by a fold, the mesonephridium, of which the upper elongated end is continued to the diaphragm (plica phrenico-mesonephrica) and the lower to the abdominal wall in the inguinal region (plica inguino-mesonephrica). A band of muscular tissue appears in the latter, extending from the genital portion of the mesonephros to the anterior abdominal wall in the region of the future inguinal ring. This ultimately becomes the gubernaculum testis in the male and the round ligament in the female. The testicle and similarly the ovary, having been differentiated from the mesonephros, begin their descent from the region of the second upper lumbar vertebra during the second month of fœtal life and reach the abdominal wall toward the end of the third month, where they remain until shortly before birth. It is obvious, then, as Jonnesco reasoned, that this descent cannot affect the cæcum and much less the ileum which at this time of fœtal life are still undescended. The upper part of the mesonephridium does, however, in certain instances remain as a fold running from the inguinal canal in the male or the broad ligament in the female upward over the iliac fascia and psoas muscle until it meets the mesentery of the ileum and so disappears from view. If the latter chances to be fused with the posterior peritoneum this fold runs directly to the point of fusion, giving the impression that it has something to do with this abnormal condition, which, as one can see from above, is not true.

Accurate statistics as to the incidence of hyperfixation of the ileum are difficult to find. Addison [81] in 40 cases described the ileum as firmly fixed in the iliac fossa in 8, or in 20 per cent. Mollison and Cameron [108] report a similar condition in 5 of 50 cases, or in 10 per cent. In 55 per cent. of Reid's [84] cases a "genito-mesenteric fold" was present, but this merely serves to show the frequency of persistence of the plica mesonephrica and does not give any information as to the incidence of ileal hyperfixation. Gray and Anderson [83] report 10 per cent. of the cases examined by them as

having a Lane's band. Leveuf [96] records its presence in 10 per cent. of the fœtuses which he investigated; Alglave [104] states that in 100 necropsies he found ileal fixation with a free cæcum in 13 per cent., with a fixed cæcum in 8 per cent. Kelly and Hurdon [118] also called attention to such fixation of the ileum.

In the autopsy examinations here reported only those incidences were noted in which the hyperfixation of the ileum was sufficient to render the terminal three inches relatively immobile. The mesentery was much more

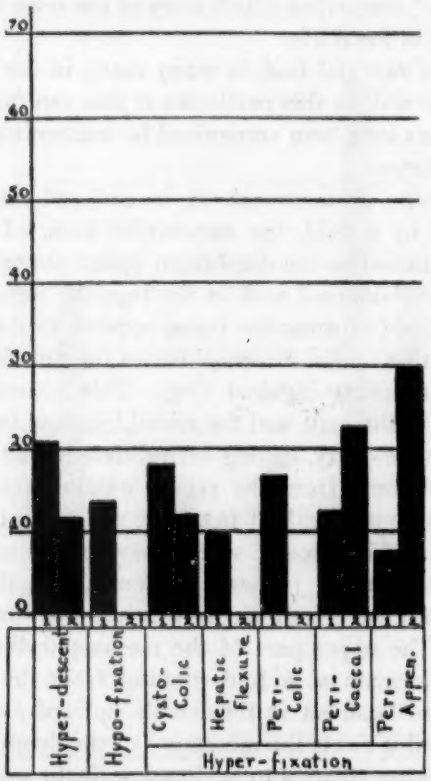

FIG. 15.—Incidence of peritoneal variations in the entire series (1) and in peri-ileal hyperfixation (2) compared by percentage.

frequently fused with the posterior parietal peritoneum for a considerable distance, but inasmuch as these did not correspond to the description of Lane they were not noted. In all, 9 instances were observed, or 8.6 per cent. of the number of infants examined (Fig. 5). Some of these were associated with the vestigial fold previously discussed, but the latter was not of necessity present.

Hyperfixation was found three times as frequently in the female as in the male (Fig. 6).

The rapid decrease in the incidence of this variation in the first year of

life as suggested by Fig. 7 is not readily explicable, but may be due to the small number of necropsies. It is apparent from the observations of other workers, whose statistics are quoted above, that this fold does persist into adult life with much the same frequency as in those infants up to two months of age.

A marked association of this abnormality with periappendicular and pericæcal hyperfixation is shown by Fig. 15, emphasizing again that these membranes are not, as Leveuf suggested, a result of a deficient involution of the omentum.

Kinking of the ileum in association with hyperfixation was observed only once.

IX. DISCUSSION

In the presentation of the data above it has been assumed that these membranes and bands found in infants during the first year of life are developmental in origin and not the result of a peritonitis. In order to assure oneself of this it is necessary to consider the following points.

Prenatal peritonitis is of itself a rare condition, only sixty cases having been reported up to 1908 (Helbing[119]), of which 25 were described by James Y. Simpson in 1838. There are in general two types, the one due to syphilis (Silbermann[120]) and the other to congenital atresia or open diverticuli with an aseptic peritonitis as a result. The picture in both of these forms is that of a chronic generalized peritonitis with adhesions scattered throughout the abdomen.

Any form of bacterial peritonitis in the fœtus is of necessity metastatic in origin and consequently of even greater rarity than a similarly caused lesion in the adult.

Postnatal peritonitis as a causative factor must, of course, be limited to those forms incidental to the first year of life. By far the most frequent is that following infection of the cord which leads to localized inflammation in the region of the umbilicus, multiple abscesses in the liver, or generalized peritonitis. Such infections are overwhelming in their virulence and certainly show no tendency to localization about the colon and cæcum.

To explain such abnormalities on the basis of a syphilitic infection requires the highly improbable assumption that something over 50 per cent. of the infants coming to autopsy in this hospital not only had syphilis, but also had a syphilitic peritonitis. (Fig. 5, column 10.) Tuberculosis requires a similar assumption.

A low-grade chronic infection such as is postulated in the hypothesis of "perienteritis membranosa" (Gerster) does not explain adequately the many membranes and bands present during the first two months of postnatal life, since such a chronic condition has hardly had time to establish itself, nor would this explain the *decrease* in the frequency of occurrence of those about the cæcum, appendix and terminal ileum as the infant grows older (Fig. 7). One would have to assume a different origin for this group

at least, which has exactly the same general characteristics as those seen higher up on the colon.

Inasmuch as the contents of the intestines are sterile until birth a pericolitis as a result of infection from the intestine previous to this event is of course impossible, and yet Flint,[81] Leveuf,[96] and others have clearly demonstrated that membranes and bands of the type under discussion are frequently found in the fœtus.

Finally, thirteen different specimens showing the most marked membranes were examined for histological evidence of inflammation of the peritoneum or its adjacent structures. Even in instances of ulcerative follicular colitis the cellular infiltration was not found to extend beyond the muscle wall of the gut. It can be stated very positively that there was no histological evidence of inflammation of the peritoneum in these cases. The following description is typical of the picture seen in these sections (Figs. 16 and 17.

Section evidently taken at right angles to the long axis of two contiguous portions of the large intestine. Stretching across the angle between these may be seen on the serosal side a band of rarefied tissue.

Under magnification the mucosa shows the normal structure of that of the large intestine. The most superficial epithelium is in places eroded, apparently the effect of postmortem changes. The glands of Lieberkühn are distended with mucus, but there is very little cellular detritus and no indication of ulceration or hemorrhage. Elsewhere there is no increase or change from the normal in the cells found in the mucosa. The vessels of the submucosa are not distended nor is there any evidence of diapedesis. The solitary lymph nodules are not unusually prominent. The muscular coats show no cellular infiltration and are in no wise abnormal. The band of tissue noted above is now seen to be made up for the most part of a very loose network of fibro-elastic tissue, covered externally by a layer of endothelial cells. In this tissue there are occasional capillaries surrounded by a few plasma cells, and not frequently one of the latter is seen at some distance amidst the fibrous strands. The normal number of fibroblasts are distributed throughout this layer. There is nowhere any suggestion of cellular infiltration or indication of an acute or chronic inflammatory reaction. The endothelial covering does not seem thicker than is normal and mitoses are not apparent.

It scarcely needs argument, once having shown the inadequacy of the inflammatory theory, to convince one of their developmental origin. Their localization at the points on the intestine where certain anatomical variations, long recognized as such, are especially prone to occur, their extreme mutability during the first year of life, their correlation with the descent and fixation of the colon and with the retrogression of the colic omentum, all point to what one might expect from such late simultaneous development, namely, the frequent formation of variations of the peritoneal attachments of the right colon, cæcum, appendix and terminal ileum.

This being true, it remains to be shown that the adhesions seen in the adult in this region of the abdomen are of the same character. It is necessary first to exclude from this consideration those adhesions which show a very

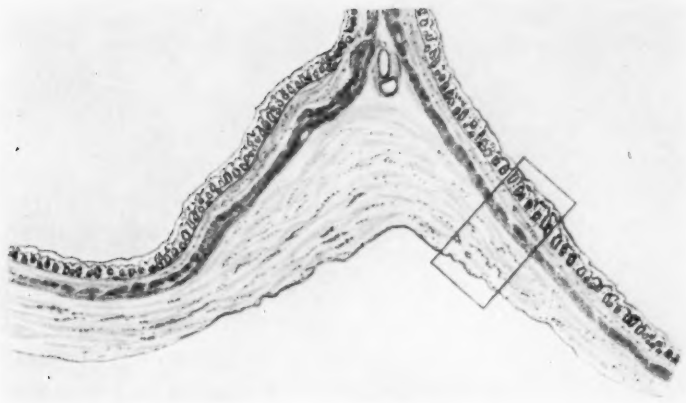

FIG. 16.—Section of peritoneal membrane from specimen of hepatic flexure hyperfixation (see Fig. 20), necropsy No. 09 (magnified x 10). Sections from tissue hardened in Zenker's fluid and stained with Delafield's hæmatoxylin and eosin and Van Gieson's connective-tissue stain. Note absence of inflammatory reaction. Enclosed area enlarged in Fig. 17.

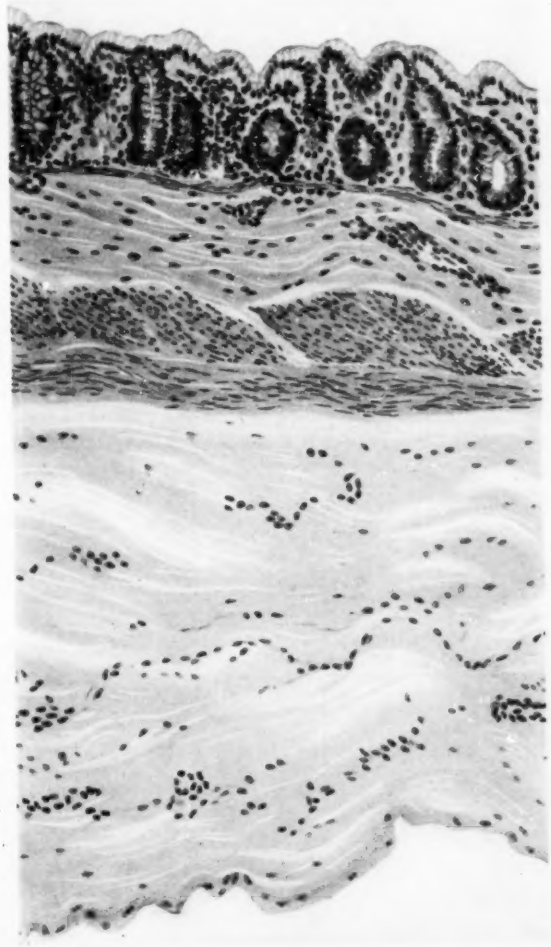

FIG. 17.—Section of peritoneal membrane shown in Fig. 16. Note absence of inflammatory reaction.

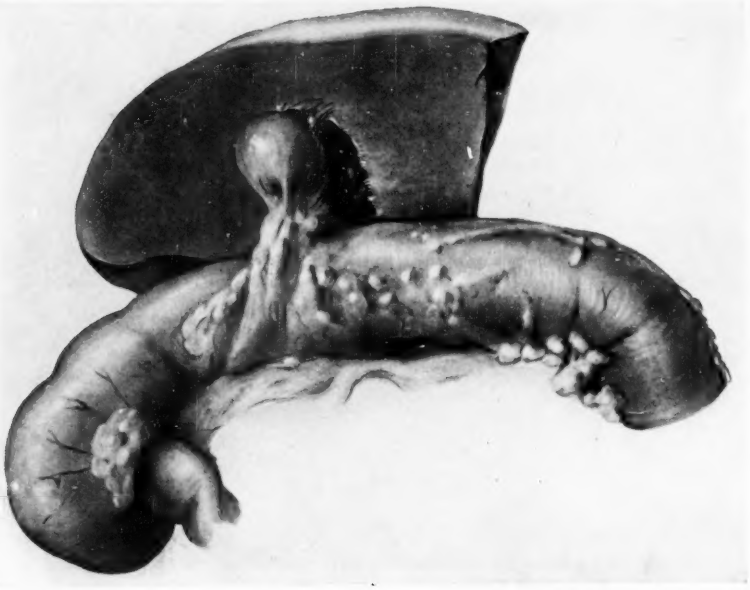

FIG. 18.—Specimen of cystocolic hyperfixation from necropsy No. 316. Note extension of cystocolic membrane upon gall-bladder and colon, also presence of fat in the band.

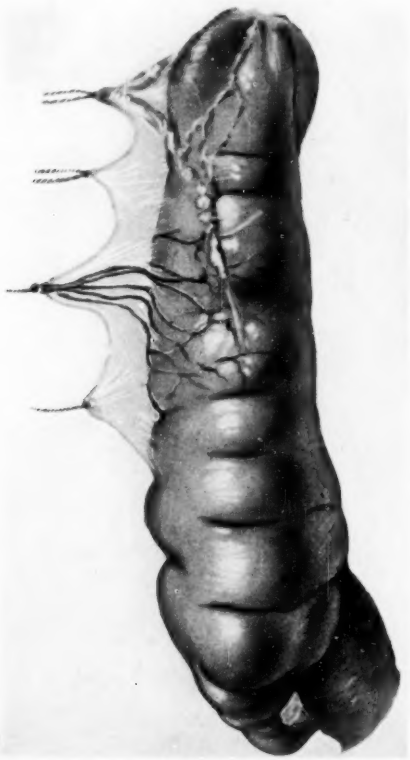

FIG. 19.—Specimen of hepatic hyperfixation from necropsy No. 281. Note extension of omentum downward upon colon and its immediate relation with the parietal peritoneum.

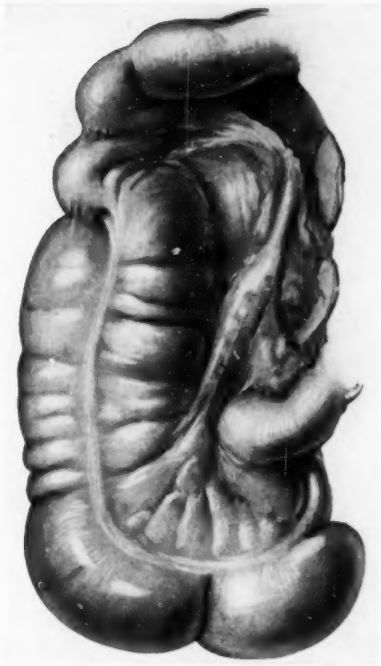

FIG. 20.—Specimen of hepatic flexure hyperfixation from necropsy No. 345. Note angulation of gut and distention of cæcum.

FIG. 21.—Specimen of pericolic hyperfixation from necropsy No. 361. Note extension over angle of gut and the junction with the parietal peritoneum.

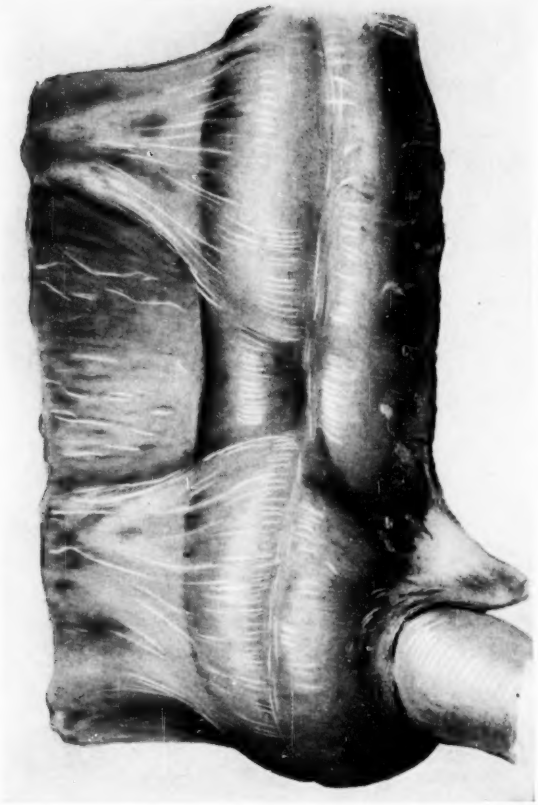

FIG. 22.—Specimen of pericolic hyperfixation from necropsy No. 256. Portion of "veil" has been torn apart to show underlying gut.

FIG. 23.—Specimen of pericæcal hyperfixation from necropsy No. 241. Note the diaphanous character of the membrane and its extension over a furrow in the gut.

FIG. 24.—Specimen of peri-ileal hyperfixation from necropsy No. 223. Note that this band does not correspond with the plica genito-mesenterica shown behind the ovary.

FIG. 25.—Specimen of peri-ileal hyperfixation from necropsy No. 266. This shows the angulation of the ileum that may be produced by this band.

apparent inflammatory etiology; that is to say, definite macroscopic or microscopic changes in the tissues primarily involved in the inflammation; in other words, those cases in which a diagnosis of inflammation or injury could be made were adhesions not present. It is also necessary to exclude certain groups of idiopathic, chronic peritonitis in which the peritoneum is very apparently primarily at fault and which present very definite clinical and pathological pictures. Such are polyserosites and proliferative and chronic hemorrhagic peritonitis. There are left then the localized adhesions about the gall-bladder, duodenum, ascending and transverse colon, the cæcum, appendix and ileum, in which no definite anatomical evidence of inflammation is present, unless the adhesions themselves are taken to be such. Are these structures in the adult of the same nature as those seen in this series of autopsies and reported by others; that is to say, are they developmental variations?

The only method which could answer this question beyond any possible objection would be to observe by many autopsies the transition of these congenital membranes from infancy to adult life and observe at frequent intervals the incidence of inflammation in the surrounding structures. This unfortunately has not been done in detail, though the observations of Toldt [5] and Albrecht [117] covered this field fairly well and led them to believe such adhesions developmental. The argument for the present must rest almost entirely on four points; namely, the similarity of location, the similarity of appearance, the insufficiency of the evidence which accredits such "adhesions" in the adult to inflammation, and the marked dissimilarity of appearance of this type from those caused by inflammation.

It is unfortunately confusing that the regions in which these membranes are found in infants are also the most frequent sites of inflammation within the abdomen. It must be granted, however, that many, perhaps the majority, of such structures in the adult show no definite anatomical inflammatory basis; that is, there is no sign of inflammation in the adjacent viscera unless the adhesions themselves are taken to be such. With this in view the similar location in the infant and in the adult is corroborative proof of their identity.

The similarity in appearance is a fact which is difficult to convey except by the actual demonstration of specimens. Drawings and specimens are, as a rule, necessarily inaccurate and limited in their portrayal of peritoneal adhesions. However, the plates shown here (Figs. 16, 18, etc.), as well as the excellent drawings in the article by Flint [81] and in the monograph by Gray and Anderson,[82] can scarcely fail to convince one that there is a remarkable resemblance between these congenital membranes and bands and those seen in a similar location in adult life. In addition we have the testimony of many observers (Flint,[81] Gray,[82] Morley,[90] Moynihan,[94] Leveuf,[96] Eisendrath and Schnoor,[95] etc.) as to the similarity, while there is, on the other hand, the one observer (Chapple [121]) stating that these structures in the adult and in the infant are dissimilar.

If it could be shown that any considerable number of the adhesions of the type under discussion seen at the operating table and at autopsy in the adult had a definite inflammatory basis, the persistence of the congenital membranes into adult life would be difficult to prove. It has been granted by most observers that the familiar acute types of peritonitis do not produce adhesions of this distribution and appearance, nor has it been suggested that the definite and well-recognized types of chronic, idiopathic inflammation mentioned above are in any wise responsible. Consequently it has been found necessary to propose and attempt to prove an hypothesis something as follows:

Fecal stagnation occurs as a result of ptosis or other mechanical obstruction (Virchow,[14] Gerster,[69] Eastman,[77] Wilms,[59] Klose,[68] etc.) or from loss of muscle tone of the bowel (Fischler[62]). The bacteria or their toxins from the dammed-back fæces pass through the intestinal wall and incite a peritonitis. The statement of such an hypothesis is simple, the proof more difficult. It rests in the first place upon the assumption that bacteria and their toxins readily pass through the undamaged intestinal wall into the peritoneal cavity. There is no proof for such an assumption. It is true that B. tuberculosi (Ravenel[122]), B. typhosi and B. coli (Franke[123]), as well as many other bacteria, pass through the intestinal *mucosa* without evident damage to it and are then carried to the neighboring lymph glands. With chylous ascites it is conceivable that they might be washed back into the peritoneal cavity, but normally the tendency is entirely in the opposite direction. It has been shown in experimental herniæ in animals that infection of the hernial sac does not occur until there is very definite injury to the wall with interference with the circulation (von Brunn[1]).

It is conceivable that an organism might develop the faculty of passing directly through the wall, as has been suggested by Bassler.[124] None of the bacteriological criteria as applied to the isolation and identification of an organism responsible for a given disease have been filled in respect to the "B. Membraformis" described by this author.

It is also conceivable, as suggested by Adami,[125] that a condition of "subinfection" may be present; that is, that organisms of low virulence are constantly passing into the blood stream. In support of this is the work of Opie,[126] in which he has shown that the simultaneous injection of B. Coli and the giving of chloroform may produce cirrhosis of the liver in dogs. It is a far cry, however, to say that the cirrhosis seen in man is produced in a similar way. Moreover, these adhesions or even intestinal stasis itself are not correlated with such a cirrhosis.

The only attempt so far on record to prove experimentally that long-continued and severe stasis in the colon produces adhesions is that reported by Eastman.[77] Unfortunately, there is no detailed report of this work including protocols of experiments and controls, so it is difficult to discuss intelligently the findings. One knows, however, that in dogs, cats and rabbits, congenital variations in the peritoneal folds are exceedingly fre-

quent and indeed the normal attachments have many times the appearance of adhesions. It is obvious, then, that only the most painstaking control of such work will suffice. It should also be borne in mind that any experimental condition which produces an actual colitis with ulceration or other evidence of severe injury to the colon does not correspond with the conditions in man, inasmuch as the great majority of the cases, so far as recorded, show no anatomical evidence of inflammation of the colic wall. That this is true even when accurate studies are carried out, of which there is a singular dearth, is indicated by the report of Keith.[97] Even in such an extreme stasis as is present in Hirschsprung's disease it is not customary to find adhesions.

As suggested by Hofmeister,[67] one might say that such adhesions were the result of a previous acute attack of appendicitis, cholecystitis, or colitis. It is, of course, exceedingly difficult to rule out such factors, especially if one grants that the "anfallsfreie Appendicitis" of Klemm is capable of the production of adhesions. It is more probable, however, that the latter is in reality a result of the mobile cæcum and the adhesions, rather than the cause. It seems in addition highly improbable that some 50 per cent. of (table, column 10) men, as indicated by the presence of membranes and bands, have had an acute inflammation without symptoms of the appendix, colon or gall-bladder.

Then, to sum up the argument against the inflammatory nature of these adhesions, there is no proof to show that virulent bacteria or their toxins pass directly through the intestinal wall without injury to it, there is no proof that the wall of the intestines in these cases has been or is the site of an inflammatory injury, and finally there is no proof that the avirulent organisms present in normal tissues ever produce an inflammatory reaction such as would be necessary to account for the formation of peritoneal adhesions. The whole argument in favor of "membranous pericolitis" as the cause of the adhesions under discussion in this paper is entirely hypothetical and as yet without any adequate evidence in its favor, either experimental or anatomical.

Then, too, there is a very definite difference in the appearance of the congenital membranes and of those of inflammatory origin. The former bear a resemblance to a mesentery, are thin and translucent, have connective-tissue strands running in parallel lines and not infrequently, especially about the gall-bladder, contain fat. In addition, in the uncomplicated case there is no scar or other evidence of present inflammatory lesion of adjacent structures. The latter are thicker and opaque, leaving the white, spider-web appearance of a cicatrix. Their connective tissue is not arranged in parallel strands, and they do not enclose fat. There is usually present some inflammatory lesion of an adjacent structure from which the peritoneal inflammation has been derived. So distinct is the difference that one can say that at this point in a single specimen the membranes are congenital and at that inflammatory, a condition not infrequently seen about the appendix, where

one type of lesion is superimposed upon the other. Such an instance is reported by Flint.

Granted, then, that these adhesions occur in the adult in the same location, that they have the same appearance, that there is no adequate evidence of an inflammatory origin, and that the appearance of the congenital and of the inflammatory type is different, then the conclusion seems fairly certain that the former are of the same character as those described in the infant and consequently developmental in origin.

Having arrived at this conclusion it becomes necessary to discuss the method of formation. Hertzler [128] has suggested that although essentially congenital these adhesions are due to varicosities arising from the dilatation of "potential blood-vessels." Such dilatation leads to a hypertrophy of the accompanying connective-tissue fibres and the formation of the membrane. This implies the finding of dilated blood-vessels in these adhesions, which is by no means the rule. In only one case observed in the series was there marked varicosity and this was venous.

Eastman,[77] Cheever,[88] Eisendrath and Schnoor,[95] and many of the more recent writers in the American literature tend to correlate these adhesions with certain anatomical structures. So the parietocolic fold becomes the prototype of the adhesions on the ascending colon such as were described by Jackson, and the plica genito-mesenterica of the adhesions about the terminal ileum. It is to be remembered that the folds and fossæ about the cæcum, appendix and ileum, although not entirely constant, are, nevertheless, definite anatomical structures. To use the names of individuals in connection with these is doubly confusing, first because the same individual has usually described many folds, and, secondly, because it is extremely difficult to ascertain to whom the true credit belongs. It seems much simpler and also more accurate to consider these adhesions as variations of physiological fusion rather than as variations of folds which they frequently but little resemble. This fusing of the peritoneal surfaces, occurring almost simultaneously with the rapid growth of the intestine, serves to explain in every detail the formation of such membranes.

To what extent such congenital adhesions are responsible for disease in the adult is difficult to say, and the data presented in this paper have little bearing on this phase of the subject. One can state, however, that in two or three specimens adhesions about the appendix were of such a nature that they might readily have produced stasis and have been an important factor in the development of an appendicitis in the manner suggested by Sprengel,[129] Dieulafoy,[130] Aschoff,[131] and Albrecht.[117] So, too, the terminal ileum in at least one case was kinked sufficiently sharply because of hyperfixation to suggest the possibility of partial obstruction, and this was also true once in the ascending colon. No instances were noted in which the adhesions about the gall-bladder, although extensive, and extending to the duodenum and transverse colon, definitely produced a kink in either the colon or duodenum. The work of Harris [132] and of Homans [133] in relation to stasis in the duodenum as a result of adhesions in this neighborhood suggest very

strongly this possibility. Although the ampulla of the gall-bladder is normally extremely convoluted, it seems quite probable that stasis in this viscus may at times, perhaps frequently, be as suggested by Gray and Anderson [83] a result of congenital variations in its peritoneal coverings, especially in the region of the cystic duct.

It is certain, indeed, that one can no longer assume a peritoneal adhesion to be pathognomonic of peritoneal inflammation. One must be careful not to make a diagnosis as to some lesion of the intestine from the presence of adhesions alone, for congenital adhesions occur in nearly 50 per cent. of normal abdomens. To put it more concisely adhesions of this type about the terminal ileum, appendix, cæcum, ascending colon and gall-bladder are in themselves of little if any value in diagnosing inflammation. Such a diagnosis must depend upon the pathological picture in the organ itself. Adhesions in these regions may be either causal or coincidental to inflammation or the resultant of it, but in the absence of anatomical evidence of injury to an adjacent viscus they are presumptively congenital and, in the presence of such evidence, very possibly so.

Whether these structures tend to progress or to retrogress as the individual becomes older is not susceptible of determination by the data here presented, inasmuch as the period of observation was far too short. It might be presumed, as was done by Riedel and Lane, that they would follow the general laws of the growth of tissues, and that strain sufficient to cause relatively slight damage would result in a certain amount of reparative effort and hence a thickening along the line of strain, while less than this would produce no change, and greater rupture of the resisting membrane. That this is true of the development of connective tissue elsewhere in the body has been shown by Flint.[134] In such a manner one could conceive of the at first delicate membrane becoming developed into a rather coarse structure as seen in the adult.

The great frequency in this series of both hyperdescent and hypofixation of the colon as well as the observations of Klose, Wandel, Dreicke, and many others indicate that the cæcum with considerable mobility is quite normal, although in a relatively few instances it may give the symptom-complex described by Wilms.

X. SUMMARY

1. Variations in the peritoneal attachments of the colon, appendix and terminal ileum have for a long time been well recognized by anatomists and pathologists.

2. Such variations are found frequently in infants, as shown by the examination of 105, between birth and 2 years of age.

3. These variations are identical with certain adhesions seen in the adult about the gall-bladder, hepatic flexure, ascending colon (" Jackson's membrane "), cæcum, appendix and terminal ileum (" Lane's band ") and frequently but wrongly ascribed to inflammation.

4. The clinical importance of such variations in relation to the syndrome of " chronic appendicitis " has in the past ten years been well demonstrated.

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THE MULTIPLE MYELOMATA AND THEIR ABILITY TO METASTASIZE

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The neoplasmic disease described under the caption of multiple myelomata is characterized by foci of growth arising in different parts of the marrow system at approximately the same time, the individual tumors springing from certain primitve cells of the blood-forming series. The disease is rare. It occurs apparently exclusively in individuals over thirty-five years of age and oftenest in men, the proportion being about three to one. Those cases which terminate within six months constitute the rule, although instances are known in which the disease has lasted from three to five years. The bones involved are those with red marrow, notably the vertebræ, sternum, ribs, clavicles, skull, scapulæ and ilium, the marrow in the ends of the long bones of the extremities being relatively seldom affected. The growth replaces the marrow and frequently erodes the bony casement in such fashion as to bring about deformities of various sorts, with or without spontaneous fracture, and is red or greyish-red, depending on the occurrence of hemorrhage or the degree of vascularity, occasionally cream-colored or whitish.

The symptomatology of the multiple myelomata depends largely on the size, number and distribution of the growths, and on the production of deformities, although the occurrence in the urine of the peculiar protein first described by Bence-Jones constitutes a symptom of great value in those cases in which tumor nodules have not yet become obvious, and of confirmatory significance in those cases where nodular or other deformities are already evident. The appearance of deformities, however, is usually preceded by a period during which the patient complains of persistent, deep-seated pains, the cause of which is not apparent and the nature of which is consequently apt to be misinterpreted as rheumatic, neuralgic or neurotic. The pain, which is almost always referred to the same region, is frequently worse at night and is accentuated by movement. In some cases it is fugitive and not very intense; at other times it occurs in paroxysms which are so severe as to incapacitate the patient for days at a time, disappearing only to reappear with equal or increased intensity. In still other cases the pain is continuous, lancinating or boring in character, and of such ferocity that the patient's fortitude is soon exhausted. Pain of the sort described, unless otherwise explicable, should arouse suspicion of a myeloma or of one of the several clinically related neoplasmic lesions of the marrow system, or of a

deposit from a primary growth whose metastases express a predilection for the bones, such as tumors of the thyroid, prostate, stomach, adrenal, etc. The use of the X-ray is helpful in determining the existence and location of circumscribed metastases, but in the case of diffuse metastatic or myelomatous infiltration of the marrow, the X-ray sometimes is powerless to register a shadow. It is an observation of value, also, that, while the presence of the Bence-Jones proteinuria is not pathognomonic of the multiple myelomata, its detection has several times led to the correct diagnosis before the expansion of the tumor nodules in the bony system had reached such a grade as to fall within the scope of ordinary diagnostic methods.

When the deformities of the bony system occasioned by the multiple myelomata become visible or palpable, the age and sex of the patient and the distribution of the tumors are sufficient to establish the nature of the process with reasonable assurance, particularly if the urine reveals the reactions for the Bence-Jones body. Primary tumors of the bony system are known, however, in which the distribution is identical with that of the myelomata, and in a few cases of metastatic carcinomata of the bones the urine has yielded the characteristic reactions for the Bence-Jones protein. In a disease described by Symmers and Vance the patient complained of exquisite pains in the back, hip and axilla, and tumors were present in the sternum, humerus, occiput, vertebræ, ribs and ilium, microscopic examination revealing multiple primary intravascular hemangio-endotheliomata with the formation of subsidiary vascular channels within many of the parent capillaries of the growth, and Seegelken has described a case in which there were multiple primary chondrosarcomata of the vertebræ, sternum and ribs. In neither case was the Bence-Jones protein found in the urine. Barry and Martland have described a condition attended by multiple tumors in the tibiæ, clavicles, scapulæ and other bones, the microscopic appearance being that of a spindle- and giant-cell growth easily distinguishable from the myelomata and other primary tumors of the bones, although the clinical manifestations are much the same. Recognition of this variety of growth is imperative, since operative removal of each growth as it arises promises a chance of cure. Moreover, the bony system may become metastasized from a clinically indetectable primary growth in such manner as closely to simulate the distribution of the myelomata. This fact is of moment in that a small primary carcinoma of the thyroid, for example, may metastasize the ribs, sternum, clavicle or other accessible bones in a way that operative interference directed toward both the primary growth and its metastases promises the only hope of relief.

Of the bones involved by the multiple myelomata the vertebræ are perhaps oftenest concerned. The process usually is first shown clinically by the appearance of pains which radiate down the legs, into the arms, or around the trunk. The distribution of the pains in the legs may be such as to suggest sciatica, and, in these circumstances, the growth is to be sought in the lumbar spine or in the sacrum. Involvement of the thoracic or lower cervical

vertebræ is attended by pains corresponding to the distribution of the superficial sensory nerves of the part or even to the visceral ramifications. In the upper cervical region the presence of myelomata in the marrow of the vertebræ is not uncommonly manifested by neuritic pains in one or both arms, sometimes associated with motor or trophic disturbances due to pressure on the upper reaches of the brachial plexus. In still other cases, the growth of the tumors in the vertebræ results in disintegration of the intervertebral discs, collapse of the bodies, the production of a kyphos and the symptoms of pressure on the cord. Several such cases have been subjected to operation with temporarily beneficial results.

In some cases the existence of myelomata is first suspected when, as the result of some natural movement or following slight traumatism, fracture ensues. The fractured bone is usually painless except on manipulation, and union does not occur even when the approximated ends are at rest. On the other hand, union has been known to result even without the aid of artificial devices, notably in the ribs.

Histogenesis.—The commencement of the process of blood formation in the bone-marrow is marked, according to Maximow, by the migration into the perichondrium of the pre-bony cartilage of certain star-shaped cells which differentiate into two primary forms, namely, fixed cells, representing the precursors of the reticulum and of the osteoclasts and osteoblasts; and myeloblasts, from which are derived the granular leucocytes and the erythroblasts. The weight of histological evidence seems to favor the view that the myeloma is a tumor composed of myeloblasts, although certain derivatives of the myeloblasts, namely, the neutrophilic myelocytes and the erythroblasts have been implicated, Ribbert having described a so-called erythroblastoma of the bone-marrow, and Sternberg and others, myelomata which were composed of what were regarded as neutrophilic myelocytes. Christian, on the basis of slight differences in the size of the cells and in the arrangement of the nuclear chromatin, distinguishes between the myeloblast and a so-called plasma-cell peculiar to the bone-marrow, from the latter of which, he assumes, a type of myeloma originates. It is to be noted in this connection that the plasma-cell of the tissues, which is found over a wide distribution and in a great variety of pathological conditions, is a cell of characteristic and easily recognizable structure, about whose origin, function and destiny, however, absolutely nothing is known. It is a morphological unit, but otherwise an enigma. The "bone-marrow plasma-cell," on the contrary, is not even a distinctive morphological unit, since it bears such a striking resemblance to the myeloblast that even experienced microscopists find it difficult, if not impossible, to differentiate between the two, as shown by the fact that, in one of Christian's cases of myeloma in which he designated the cells "bone-marrow plasma-cells," the same tumor, examined by MacCallum, was interpreted as a growth of myeloblasts. With Forman and Warren, I have had occasion to observe, in one and the same tumor, cells which, according to the criteria advanced by Christian, could be interpreted as myeloblasts,

while in the same field were numbers of cells which, by the same token, would be regarded as plasma cells of the so-called bone-marrow type. It seems to me that they represent slightly different stages in the development of the same cell. The oxydase reaction which, in theory at least, should permit differentiation between the plasma-cell and myeloblast, does not always fulfil its promise in this respect, and, indeed, this is to be expected, for the reason that the oxydase reaction is a phenomenon whose occurrence is subject to the vagaries of living cells. Because the myeloblasts of the normal marrow and of some myelomata yield a positive oxydase reaction is no sign that the myeloblasts of all myelomata should be similarly responsive. A positive oxydase reaction is of distinct value, but a negative reaction is, I believe, meaningless as far as the recognition of the neoplasmic myeloblast is concerned. Interesting in this connection is an observation of Dr. Alexander Fraser, who, in attempting to differentiate between the cells in the exudate of croupous pneumonia by means of the oxydase test, found that morphologically typical polynuclear neutrophiles not uncommonly failed to respond, while other neutrophiles in the same microscopic field reacted definitely. From this it is to be assumed that the polynuclear leucocyte either loses the ability to react in certain circumstances or that it sometimes fails to acquire it, and the same would appear to be applicable, possibly with even greater force, to the myeloblast which is proliferating rapidly and under the influence of an abnormal stimulus such as obtains in the process of myelomatosis. In the myeloma studied by Forman and Warren, the oxydase reaction was positive, the granules occurring in the great majority of the tumor cells, not alone in those cells which, morphologically, were indistinguishable from the plasma-cell described by Christian, but in those cells whose structure entitled them to classification as myeloblasts. These investigators infer from this observation that many of the myelomata which have been described as plasma-cell tumors were probably composed of myeloblasts. In Vance's case of myeloma, in which the cells were of the myeloblastic variety, the oxydase reaction was negative. In both of my cases of myeloma it was likewise negative, one of the tumors showing a preponderance of cells of the sort described by Christian, the other composed largely of myeloblasts with a pronounced admixture of so-called plasma-cells and of degeneration forms.

Unlike the plasma-cell, the myeloblast is a cell about whose genesis and derivatives there is certain definite information. Although the plasma-cell of the tissues is a characteristic architectural entity, beyond that practically nothing is known of it. To postulate a variety of plasma-cell peculiar to the bone-marrow and the origin of a tumor from it, not only challenges assent without proof, but constitutes an assumption which does not seem to be warranted by the desirability for such an interpretation, since it does not make for clarity and must remain valueless as a working hypothesis until the cycle of the plasma-cell is determined with something akin to finality. Until that time, and until the existence of a type of myeloma composed of erythro-

blasts or of neutrophilic myelocytes is more securely established, I can see no justification for disregarding the view that the myeloblast is the only cell from which it is possible for a genuine myeloma to spring.

Since the establishment of the Pathological Laboratories at Bellevue Hospital twelve years ago only three cases of multiple myelomata have been encountered in over 6000 autopsies. One of these cases has been studied and recorded by Vance, the other two are included in this paper. Of these, one was a case marked by certain instructive clinical features, by exceptionally widespread growths, particularly in the skull, by an unusually rapid course, and, histologically, by the occurrence of tumors composed of cells morphologically indistinguishable from myeloblasts, but which failed to respond to the oxydase reaction. The other was a case attended by apparently genuine transplantation metastases in the intercostal muscles and in the fat around one of the suprarenal capsules.

CASE I.—The patient, a man aged thirty-seven years, a painter, was admitted to the medical service of Doctor Guile, at Bellevue Hospital, with the statement that, seven weeks previously, he experienced throbbing pains in the outer half of the left clavicle attended by slight redness and swelling of the affected region. The pains soon spread to the middle of the clavicle and, finally, to the sternoclavicular joint, which became painful, swollen and slightly reddened. Three weeks later the region of the right knee-joint became reddish and was the seat of violent, throbbing pains. At the same time pains of a similar description appeared in the region of the ribs corresponding to the anterior axillary line on both sides of the body, and in the right clavicle. Synchronous with the appearance of the pains in the left clavicle a swelling became evident on the right side of the forehead, and was rapidly followed by other nodules in the skull. There was no headache, but the patient complained of inability to sleep because of the pains in the several parts of the bony system involved. At the time of admission physical examination showed two nodules beneath the skin covering the forehead, that were soft in consistence. One was slightly tender, the other was not tender at all. The left sternoclavicular joint was enlarged to form a globular, tender mass which felt cystic. The outer half of the right clavicle was tender and showed two irregular, nodular areas of thickening. The ribs showed several tender nodules covered by apparently intact bone. The region of the head of the right fibula was tender, as was that of the inner side of the lower end of the right femur. During the patient's stay in the hospital the nodules in the skull increased in number, the clavicles yielded distinct crepitus, and crepitus was felt in the head of the right fibula and in the ribs. About three weeks after admission the patient exhibited slight œdema of both eyelids on the right side, and complained of throbbing sensations in the eye itself. Ophthalmoscopic examination of the eye ground on the right side showed some congestion of the veins of the fundus.

The urine revealed the characteristic reactions for the Bence-Jones protein on innumerable occasions.

At the time of admission examination of the blood showed 12,000 white cells, of which 77 per cent. were polynuclear neutrophiles, 15 per cent. lymphocytes, 3 per cent. myelocytes, and 5 per cent. large mononuclear cells. Three weeks later the differential count was about the same, although the myelocytes were present to the extent of 5 per cent.

Autopsy (No. 5692).—The body was that of a markedly emaciated man, thirty-seven years of age. On the anterior surface of the right forehead about 2 cm. beyond the middle line was an irregularly rounded, soft, almost fluctuating projection which measured 4 cm. in diameter. The right pupil was in mid-dilatation and the left was almost completely dilated. In the region of the left sternoclavicular articulation was a large rounded mass, the skin over which was intact. On palpating this mass, which was soft in consistence, a fine, crackling sensation was imparted to the finger. Over the right clavicle, at the junction of the outer third with the inner two-thirds, was a mass which likewise yielded distinct crepitation. The anterior surface of the chest was flattened, the sternum having fallen in, so that the costochondral articulations on both sides were noticeably angulated. Crepitation could be felt over several of them. Moderately soft, rounded or oval nodules could be felt beneath the skin over certain of the ribs on both sides of the body.

On removing the lungs there was found on the right side of the intrathoracic portion of the body of the fourth dorsal vertebra a rounded, rather soft projection which measured 5 cm. in diameter and was covered by intact pleura. The seventh rib on the left side presented a long cylindrical swelling which was enclosed by apparently intact bone. On section, the swelling corresponded to greyish tumor which completely replaced the marrow for a distance of several centimetres in the long axis of the bone. The sixth and ninth ribs on the right side near the costochondral junction showed similar swellings.

On opening the right femur a large, irregularly rounded, reddish, softened tumor mass was found near the lower end. A similar but smaller mass was present in the head of the right fibula.

On reflecting the scalp the calvarium was found to be riddled with large and small tumors which varied in size from the head of a pin to several centimetres in diameter. The smaller ones gave a moth-eaten appearance to the calvarium, being present, literally, by dozens. Some lay in the marrow and were enclosed by intact bone; others had pushed their way through the bony substance and lay flush with the outer surface of the skull, the bone over them having been completely replaced or remaining as a fine parchment-like sheet riddled with minute openings. Several of them, however, projected inward and pushed the dura before them, none of them actually penetrating the dura. On section they presented a soft, deep bluish or bluish black appearance, with scattered greyish islands of tissue. On either side of the head, corresponding to the temporal bone just back of the outer angle of the palpebral fissure, tumor nodules projected directly inward and through the orbital plates of the frontal bones, pressing upon the external fibrous covering of the eyeballs. The right middle fossa presented a large, globular swelling which pointed upward into the cavity of the cranium for a distance of about 2 cm. It was covered by a thin shell of finely reticulated bone. On cutting into this mass it was found to consist of a quantity of soft, hemorrhagic tumor tissue extending directly into the cavity of the middle ear.

Histology.—Sections were removed from tumors in various parts of the body. The prevailing cell was rather large, rounded or polygonal, depending upon the degree of pressure, with slightly basophilic cytoplasm and a vesicular, excentrically placed nucleus and a delicate chromatic reticulum along which were

scattered coarser chromatin particles. The cells were supported by a fine connective-tissue reticulum. In places the growth was richly vascularized, in other places hemorrhagic.

The Metastasizing Myelomata.—A noticeable feature of the myeloma consists in a tendency on the part of the growth to confine itself to the marrow system. In fact, it is frequently stated that, while the growth may erode the bony casement and bring about continuate infiltration of adjacent structures, it does not produce metastasis by transplantation of cells, either in the marrow itself or in alien tissues. It is quite generally agreed that each myeloma represents a primary growth, that each tumor arises in response to the same sort of stimulus, and that the presence of hæmopoietic tissue, if not a prerequisite to development, is at least a preferential medium. In view of the fact that hæmopoietic tissue is known to exist in certain localities beyond the confines of the bony system, it seems reasonable to assume that myelomata might develop in such tissue, either in the form of growths independent of those in the marrow and yet arising in response to the same provocative agent, or, possibly, as the result of the implantation in prepared soil of tumor-cells from a growth in the marrow.

In embryonal life the liver and spleen are hæmopoietic organs auxiliary to the bone-marrow, but in extra-uterine life the marrow assumes the task of hæmatogenesis to the exclusion of the liver and spleen, although their function in this regard may be at least partially reawakened if, for any reason, the marrow is so altered that its blood-forming function is diminished. It is known, for example, that, in pernicious anæmia and other conditions attended by interference with regeneration of blood-cells, myeloid foci are sometimes present in the liver and spleen, and it is commonly held that they represent hyperplasia of pre-existing hæmopoietic tissues in which the function of hæmatogenesis has been recalled. That this reversion may proceed to a marked extent is indicated by those extraordinary examples of acute myelogenous leukæmia in which the bone-marrow reveals not the slightest indication of hyperplastic reaction, but displays a poverty of cells or is actually sclerotic, the flooding of the circulation by myelocytes being accomplished, it is maintained, as a result of the activity of the rejuvenated hæmopoietic tissues in the liver, spleen and elsewhere. In other circumstances the presence of myelocytes and myeloid giant-cells in such tissues as the spleen and liver is explained on the basis of embolism from the bone-marrow, and, since the recipient tissues were originally members of the hæmopoietic system, it is to be assumed that they still offer an attractive lodgement for cells from the bone-marrow, and even a favorable medium for proliferation. These views are of practical importance in the interpretation of those cases of myelomatosis in which tumors of a nature identical with those in the bone-marrow are found in tissues outside the osseous system.

Cases have been recorded under the title of multiple myelomata in which so-called metastases were described in different parts of the body, but

in several of these cases the nature of the neoplasmic process in the marrow is open to serious doubt. In the case recorded by Herrick and Hektoen, the sternum, ribs, spine, skull and humerus were involved by a tumor the cells of which were apparently of the lymphoid series, and both ovaries contained nodules of the same cellular composition. The same objection applies to the cases of Weber, Scheele and Herxheimer, and Kahler, in all of which there is doubt as to the propriety of including the growths in the marrow in the category of the myelomata. In other recorded cases, however, the diagnosis of myeloma is entirely acceptable. In the case of Hoffman the tumors in the bony system were distributed in characteristic fashion, and the cells were myeloblasts. The liver enclosed nodules of identical composition with the growths in the marrow. In a case recorded by Charles and Sanguinetti, the vertebræ and ribs were involved by multiple growths of myeloblasts. Lymph-nodes enlarged to the size of filberts were found over the right common iliac artery, and contained cells of the same sort as those encountered in the medullary tumors. There was no erosion of the vertebræ and the enlarged nodes were obviously independent of any source of direct infiltration. In one of Christian's cases, the skull, ribs and vertebræ were involved and there was a nodule in the axilla and neoplasmic foci in the soft tissues of the arm. In Shennan's case, the liver revealed nodules associated with myelomata of the ribs, and in the case of Schütz the right tonsil was involved. In a case reported by Pepper and Pearce, the spleen was diffusely infiltrated by tumor-cells identical with those encountered in multiple growths in the ribs, pelvis and vertebræ, and similar cells were arranged focally in the liver.

It is a significant fact that, with the exception of a case recorded by Christian, all of the so-called metastatic deposits referred to occurred in tissues which, in embryonal life, are part of the myelocytic hæmopoietic system; namely, the liver, spleen and lymph-nodes. In the liver and spleen embryonal hæmopoietic foci are well recognized and are composed largely of myeloblasts. That the lymph-nodes, however, are part of the extramedullary myelocytic hæmopoietic system is not so generally accepted. Nevertheless, in certain aplastic lesions of the bone-marrow, Butterfield has noted the presence of typical myeloid foci in the lymph-nodes, so that the interpretation appears to be allowable that myelomatous formations in the lymph-nodes may be produced by hyperplasia of residual myeloblastic foci. In Christian's case, of course, a similar interpretation would be strained, since it presupposes the existence of myeloblastic hæmopoietic tissues in parts where they have never been demonstrated. It seems more reasonable, therefore, to regard the nodules in his case as genuine transplantation metastases.

In connection with the question of metastasis in myelomatosis by the transplantation of cells, the following case is significant:

CASE II.—A man, aged fifty-one years, was admitted to Bellevue Hospital in a semicomatose state with the classical signs of cardiac decompensation. It was learned, however, that eight years before admission the patient suffered a fall, striking the right shoulder. For a year thereafter the shoulder was more or less swollen and painful. For three months previous to admission the patient complained of rheumatic pains in the right shoulder, and finally lost the use of the arm entirely, but whether suddenly or not the history does not state. Physical examination showed marked enlargement of the heart and a double murmur at the base. The head of the right humerus was markedly enlarged and crepitation was felt. The urine revealed no Bence-Jones protein.

Autopsy (No. 4674).—The body was that of a negro man, fifty-one years of age, of well-developed frame. On the side of the head, about 3 cm. back of the external angle of the left eye, was a slightly elevated, circular growth which projected directly through the outer table of the skull and was delimited by a rim of bone. The skin over it was intact. The upper third of the right humerus was greatly enlarged and the bone was fractured. The medulla of this part of the humerus was occupied by a quantity of greyish red, soft tumor material. In the medulla of the third rib on the right side about an inch from the costochondral junction was a small, reddish nodule, soft in consistence, the hard bone on either side being intact. In the intercostal muscles between the sixth and seventh ribs on the right side was a mass of reddish tumor tissue, the ribs on either side being intact. Lying in the fat tissues immediately adjacent to the left suprarenal capsule was a soft reddish nodule which was rounded and measured 1.5 by 2 cm. The vertebræ were intact throughout.

Histology.—Microscopic examination of the tumors in the humerus, in the third rib, in the intercostal muscles and in the fat around the adrenal revealed growths composed, for the greater part, of rather large, rounded or polygonal cells, each of which enclosed an excentrically placed nucleus with a fine chromatic reticulum and coarser chromatic particles arranged at irregular intervals against the cell membrane. The cytoplasm was pale or slightly pinkish in color and smooth. Scattered among these cells, which were of the type usually described as myeloblasts, were fairly large numbers of cells whose nuclei presented slightly different structural characteristics in that the chromatic network was stippled with coarse granules, thus corresponding to the nuclei ordinarily encountered in the so-called plasma-cell. In certain sections a third type of cell was found, likewise in fairly large numbers. These cells varied in size. Each was provided with a densely staining, small nucleus, often excentrically placed, and with very finely granular, reddish staining cytoplasm. They were evidently degeneration forms.[1]

This case and the case recorded by Christian, in which there were secondary neoplasmic nodules in the soft parts of the arm and in one axilla, appear to represent the only really indisputable examples of genuine metastatic myelomata to be recorded, both of them effectually violating the generally accepted dictum that the myelomata do not metastasize by cell transplantation.

[1] Cells of an exactly similar type were described by Vance in his report of a myeloma studied in this laboratory. These cells, I take it, are the same as those described by Ribbert as erythroblasts.

CONCLUSIONS

1. The so-called multiple myelomata represent neoplasmic growths which spring from myeloblasts.

2. Since the term multiple myelomata is broadly inclusive, the designation of the neoplasmic disease under consideration might, I think, appropriately be changed to that of multiple myeloblastomata.

3. The multiple myeloblastomata are capable of originating growths in the extramedullary hæmopoietic viscera by hyperplasia of pre-existing myeloblastic foci, and in certain other tissues by the process of metastasis by cell transplantation.

THE PROGNOSIS AND TREATMENT OF EMPYEMA

WITH RESPECT TO THE SHAPE OF THE CAVITY AND THE RELATION OF THE LUNG TO THE CHEST WALLS*

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As a result of general familiarity with the use of the hollow needle, the diagnosis of acute empyema has become increasingly easy. Prognosis, on the other hand, more especially in respect to ultimate cure, is uncertain. Why in one instance a very large foul cavity heals rapidly and in another a cavity apparently more susceptible of closure is never obliterated is a matter of considerable obscurity. Patients suffering from empyema are not on the whole attractive subjects for study, yet a close inquiry into the process of healing is not without its fascination, and perhaps profit.

Healing in acute empyema takes place under a number of favorable influences, among which the following appear to be the most important: The fact that the thorax can easily be drained at its most dependent point; the remarkable circumstance that, when infected, the pleural surfaces tend to become covered with a thick layer of fibrin slowly organized and correspondingly slow to adhere to an opposing surface; the ease with which negative pressure within the thorax is restored after operation; and the very considerable collapse of which the walls of at least one side of the thorax are capable, thereby rendering a complete reëxpansion of the lung unnecessary. These influences are to a great extent interdependent. Each is worthy of separate consideration.

The ease with which the chest is drained is accounted for by the shape of the diaphragm which makes a deep narrow angle with the chest wall: Thus the chest is deepest where it is most accessible, and drainage in the posterior axillary line is perfectly dependent with the patient in a reclining position. Rapid conquest of infection is thus favored.

The failure of the pleural surfaces to adhere readily was pointed out by Schede [1] many years ago. He alluded particularly to the heavy fibrin membrane which makes the healing of long-established empyema so difficult; but in reality the active formation of fibrin on the pleural surfaces has a more important significance. If the pleura had, in empyema, the same characteristic adhesiveness as the peritoneum, the collapsed lung could never expand, and few cavities would close. The abundant secretion of fibrin so generally noted at operation is, therefore, conservative, and the very slowness with which the bloodless fibrin layer adheres to an opposing surface is a positive aid to expansion of the lung. It appears to be true that in its first

* Read before the Boston Surgical Society, April 1, 1918.

deposition, in pleurisy, as a thin layer, the fibrin covering the pleura is rapidly organized and a source of early adhesion. As a thick layer in fully developed empyema it tends, perhaps, to act at first as a lubricant; when finally organized it becomes a very avascular scar tissue, capable for months or even years of being stripped cleanly from the lung or chest wall, and leaving behind only a few small bleeding points upon a normal pleural surface. If applied to a similar opposing surface it slowly adheres.

There are problems here to be worked out. Is the fibrinous exudate a characteristic reply to the pneumococcus? Or is it due to physical and chemical characteristics of the pleural surface? Why, since the pleura offers to the pathologist the most beautiful demonstration of the organization of an exudate, is the organized fibrin layer of empyema so bloodless? How is it possible to strip it for years after its formation without injury to the lung?

The restoration of negative pressure within the thorax is, of course, the influence which expands the lung. Artificial means of establishing it are, as a rule, unnecessary. Even before the wound in the thorax is smaller than the primary bronchus leading to the collapsed lung, the wet dressing acts somewhat as a valve. Later, as the opening closes, coughing and active respiratory movements tend to inflate the lung.

In this connection the operation for acute empyema advocated by Lilienthal [2] is of interest. To widely open the chest by rib spreading, to thoroughly cleanse and free the pleural surfaces, encouraging the lung to immediate expansion, should hasten healing. The possibility of splitting the friable parietal pleura into the diaphragm or the mediastinum may prove to be a real danger. The operation is not yet established for routine use even among patients presumably able to bear it, and its advocates advise preliminary aspiration drainage in particularly sick and toxic patients.

The reduction of the capacity of one side of the thorax is brought about by the rise of the diaphragm (always noteworthy as demonstrated in Röntgen plates); by the curvature of the spine *away* from the diseased side, allowing the ribs of that side to fall together from above downward; and by the drawing over of the mediastinum (most easily noted by change in position of the heart shadow).

If one follows the healing of an acute empyema both clinically and in a series of stereoscopic plates, one is able to appreciate in most instances the steady and apparently resistless effect of these four favorable influences. One is able, likewise, to note their failure under unusual conditions. Studies made at the Peter Bent Brigham Hospital during the last four years bring out the fact that the failure of the lung to remain free, particularly the failure of certain portions of the lung to remain free in the early stage of convalescence is the usual origin of the chronic empyema cavity. In this connection it will occur to everyone equally familiar with the disease in children and adults that in operating on children, especially those whose chests are small enough to be fairly well explored with the finger, the surgeon can usually assure himself that the lung is free to expand. More particularly,

Lloyd [3] has demonstrated in children that by making a large enough incision it is quite possible and of definite advantage completely to free the lung of adherent fibrin masses and obtain immediate expansion. In adults, on the other hand, one may find, as a result, perhaps, of neglect in an acute case, that the lung is already firmly adherent, and on account of the size of the cavity and difficulty of orientation be unable to free it. It is, I believe, correct to say that as compared with adults the acute empyema of children heals more promptly and effectively.

Theoretically, an absolutely non-adherent lung should be the ideal finding in acute empyema, but it has appeared in the Brigham series that while adhesion of the lung in certain positions is most disadvantageous, in others it is actually favorable to healing. Notably, collapse and adherence to the mediastinum of the lower circumference, which normally fits into the costo-diaphragmatic angle, makes expansion impossible. On the other hand, if the lower angle becomes fixed well out upon the diaphragm, expansion seems always to occur. This condition has so frequently been found in the Brigham series and has proved to be of such favorable significance as to suggest an inquiry as to how it comes about. In one instance (Case I) a pleurisy is known to have preceded by some months the pneumonia which resulted in empyema, and indeed such adhesions, due to earlier pulmonary disturbances, may well be expected in adults. It is also conceivable that, in a lower lobe pneumonia, the inferior surface of the lung may often become sufficiently fixed during the course of the disease to remain adherent to the entire surface of the diaphragm when the rest of the lung is pressed away from the chest wall by the gathering exudate. The position of the apex at an early stage seems to make very little difference. Even when it has remained collapsed for a long time, expansion may take place provided the lower angle is in good position.

In general, if attachments of the lung occur in such a way as to leave the surface of the collapsed lung convex after drainage, complete expansion cannot occur. If, on the other hand, the lower angle of the lung becomes fixed at or near its natural position so as to leave the outer face of the lung concave, that concavity can quite readily belly out and become applied as a convex surface to the chest wall. The matter seems to be one of available lung surface. If, early in healing, the available lung surface which can be applied to the chest is limited, expansion will be incomplete. If enough surface is available the lung will always, even if slowly, fill the thorax.*

The following silhouettes taken from stereoscopic plates illustrate the course of the disease in a number of typical cases. The diagrams are accurate in showing two dimensions of the cavities, which are colored solid black. The curve of the diaphragm is drawn as a solid line and the heart shadow shown by broken diagonal lines. Curvatures of the spine are indicated. The chest is seen from behind.

* The exception to this rule is due to the complication of a bronchial fistula which, of course, prevents the establishment of negative pressure within the thorax.

CASE I.—*Apex and lower angle in good position. Concave surface* (Figs. 1–4). D. W. C. Surg. 4147. Acute right-sided empyema following pneumonia. The patient had previously suffered from a fibrinous pleurisy which had left very high diaphragm and had, perhaps, fixed the lower angle of the lung.

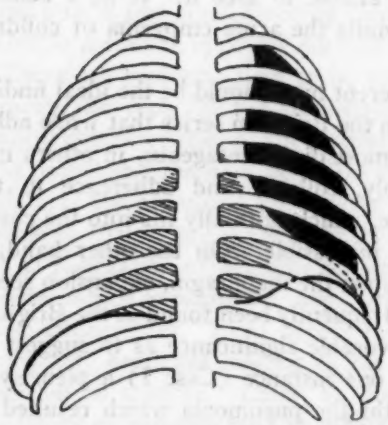

FIG. 1.—Case I. January 18, 1916. Shows condition the day before operation. Note high diaphragm on side of empyema. Patient had had a pleurisy on this side some months before.

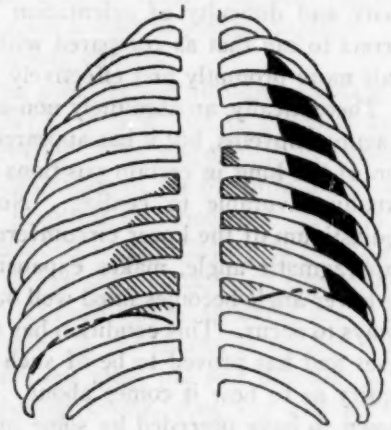

FIG. 2.—Case I. One week after operation.

Fig. 1, January 18, 1916, shows condition the day before operation. Note high diaphragm on side of empyema. Patient had had a pleurisy on this side some months before.

Operation (January 19, 1916).—Drainage by rib resection. The

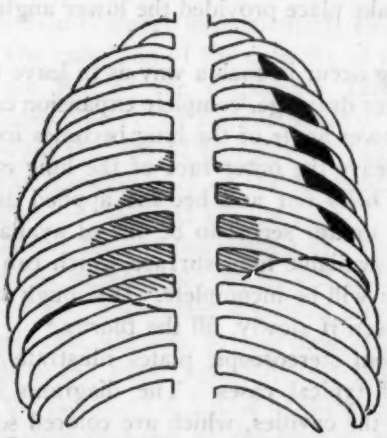

FIG. 3.—Case I. Two weeks after operation.

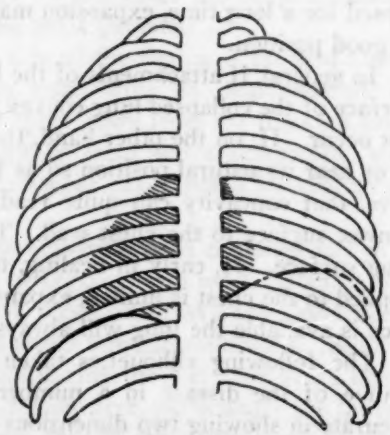

FIG. 4.—Case I. Four weeks after operation. Cavity obliterated.

empyema cavity was principally anterior and the opening was necessarily made in the anterior axillary line, a position rather unfavorable for drainage.

Fig. 2 shows condition one week after operation. Fig. 3, two weeks

after operation. Fig. 4, four weeks after operation. Cavity obliterated. The sinus was healed February 17, 1916, one month after operation.

Result June, 1917—well.

CASE II.—*Apex collapsed, lower angle in good position. Concave*

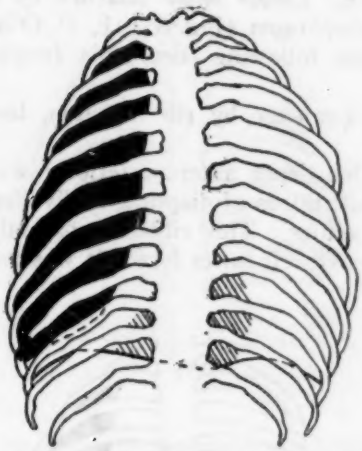

FIG. 5.—Case II. Soon after operation. Upper lung completely collapsed. Lower angle well filled. Heart pushed to right.

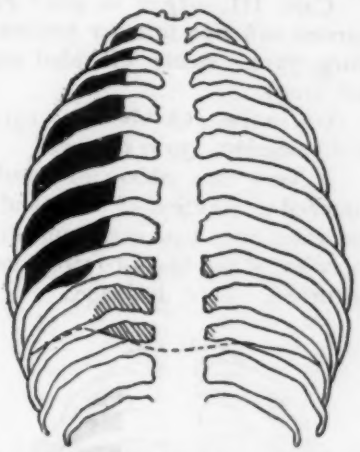

FIG. 6.—Case II. May 19, 1916. Partial expansion. Heart in normal position.

surface (Figs. 5–7). T. J. G. Surg. 4483. Subacute left-sided empyema of unknown etiology of two weeks' duration before entrance to hospital. Pyopneumothorax.

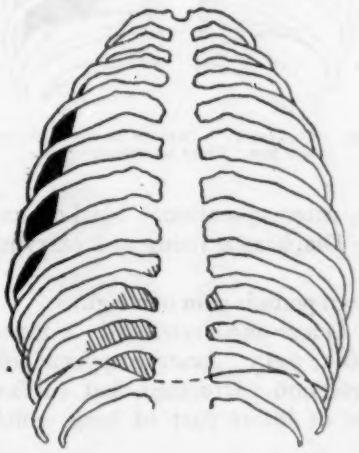

FIG. 7.—Case II. January 31, 1917. Cavity nearly obliterated. Pleura thickened.

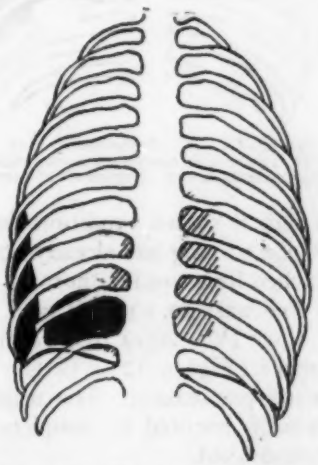

FIG. 8.—Case III. Four days after operation. Marked expansion of lung has already occurred. Diaphragm rising and carrying attached lung toward thoracic wall.

Operation (March 27, 1916).—Drainage by rib resection. Lung found collapsed above but adherent well out into costodiaphragmatic angle below.

Fig. 5 shows condition soon after operation. Upper lung completely

collapsed. Lower angle well filled. Heart pushed to right. Fig. 6, May 19, 1916, partial expansion. Heart in normal position. Fig. 7, January 31, 1917, cavity nearly obliterated. Pleura thickened.

Result June, 1917—well.

CASE III.—*Apex in good position. Lower angle attached by a narrow adhesion to outer portion of diaphragm* (Fig. 8). E. P. O'N. Surg. 7511. Acute left-sided empyema following pneumonia (entire left lung).

Operation (October 10, 1917).—Drainage by rib resection, low and posterior. 3000 c.c. pus.

A very thin ribbon of considerable depth anteroposteriorly was attached to junction of outer and middle thirds of diaphragm, dividing the chest into two communicating cavities. This ribbon apparently represented the fibrin-covered compressed left lower lobe. It was not disturbed. Tube drainage.

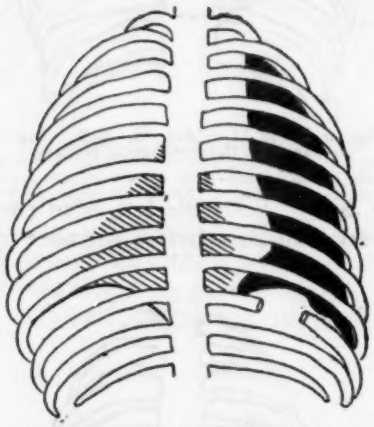

FIG. 9.—Case IV. September 9, 1914. One month after original operation. Lower angle adherent to mediastinum. Surface of lung convex.

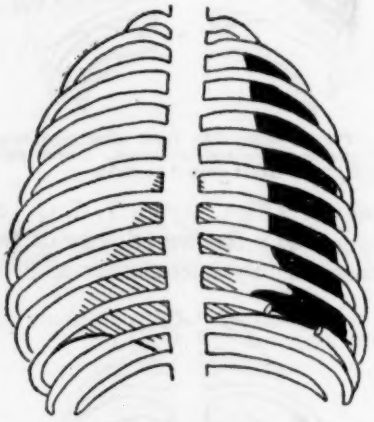

FIG. 10.—Case IV. October 28, 1914. Lower angle free. Slight lateral curvature.

Fig. 8 shows condition four days after operation. Marked expansion of lung has already occurred. Diaphragm rising and carrying attached lung toward thoracic wall.

February 20, 1918: Healed. Eighteen pounds gain in weight.

CASE IV.—*Apex in good position. Lower angle retracted. Convex surface* (Figs. 9–12). G. G. Surg. 1661, 2215. Acute empyema following pneumonia. The usual rib resection performed, but suction drainage resulted in complete collapse of lower part of lung which became fixed.

Fig. 9, September 9, 1914, one month after original operation. Lower angle adherent to mediastinum. Surface of lung convex. Decortication advised.

Operation (September 9, 1914).—Decortication by rib spreading approach in fifth interspace. Lung freed and expanded at once. Suction drainage again resulted in collapse of lung and again fibrin layer was removed and lung freed.

Fig. 10, October 28, 1914, lower angle free. Slight lateral curvature. During November, 1914, drainage opening closed and opening had to be reëstablished. Fig. 11, December 31, 1914, lung expanding and is fairly well out upon diaphragm. Fig. 12, October 28, 1915, cavity

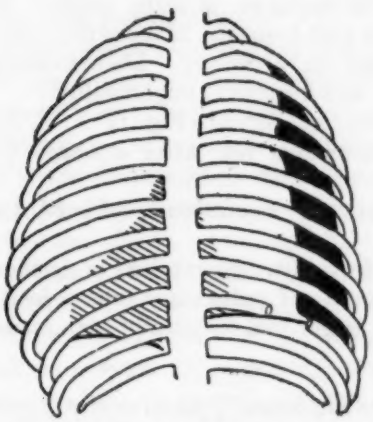

FIG. 11.—Case IV. December 31, 1914. Lung expanding and is fairly well out upon diaphragm.

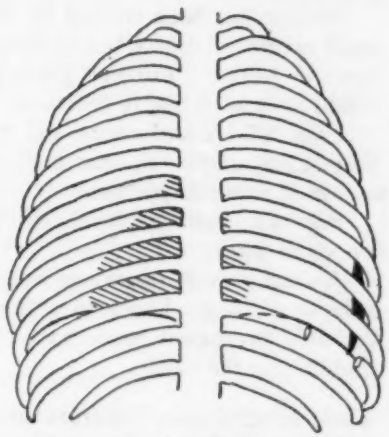

FIG. 12.—Case IV. October 28, 1915. Cavity almost healed. Unusual lack of chest deformity and rising of diaphragm.

almost healed. Unusual lack of chest deformity and rising of diaphragm.

Result, March, 1917—well. It is interesting to note that clubbed fingers developed in this case and later returned to normal.

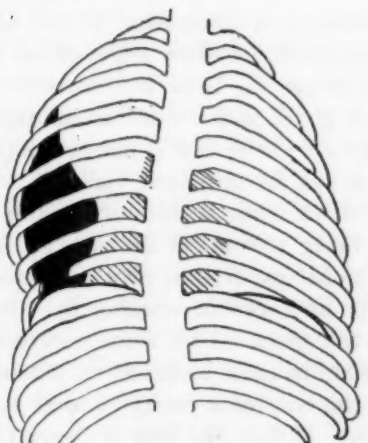

FIG. 13.—Case V. Shows upper lung filled out. Lower angle retracted against pericardium. Unusual spinal curvature which has diminished the breadth of lower part of cavity.

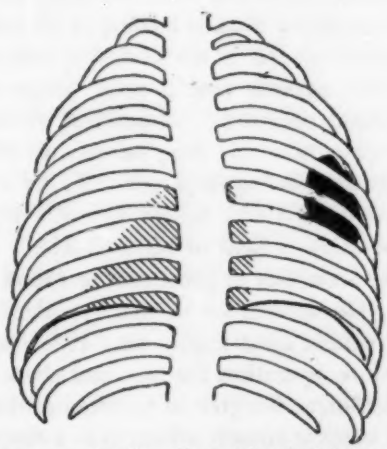

FIG. 14.—Case VI. Unusual localized failure of expansion explained by bronchial fistula.

CASE V.—*Apex in good position. Lower angle retracted. Convex surface* (Fig. 13). M. B. Surg. 4440, 5739. Chronic empyema of five years' standing, following drainage of acute empyema. Patient

exhibited retarded development and pronounced signs of chronic pulmonary infection. Foul cavity.

Fig. 13 shows upper lung filled out. Lower angle retracted against pericardium. Unusual spinal curvature which has diminished the breadth of lower part of cavity.

Patient has been treated by Schede operation in many stages. A small cavity still exists, but is clean and well drained. Marked improvement in health. Further plastics may be necessary. Decortication would have been highly desirable, but was a surgical impossibility.

CASE VI.—*Local cavity due to bronchial fistula* (Fig. 14). M. C. Surg. 4418, 4898. Patient entered hospital a year after drainage of neglected acute empyema.

Fig. 14, unusual localized failure of expansion explained by bronchial fistula.

A local Schede operation was performed which resulted in further collapse of lung. Death in a few months of pulmonary tuberculosis. Probably the patient would have lived longer had no attempt been made to obliterate the cavity.

These selected cases illustrate the more important types of cavity observed in this series. Robinson [4] has called attention to yet others and has described very perfect methods of closing chronic cavities by plastic operation. Both Robinson and Beckman [5] have called attention to the effect of perfect drainage upon even very aged infected empyema cavities and have shown that if this step is taken as a preparation for a plastic operation the plastic operation is often unnecessary. No one, however, as far as I know, has consistently attempted to base the prognosis and treatment, in either acute or chronic empyema, upon the shape and situation of the cavity. In this series the tendency toward healing in all cases in which the lower angle of the lung is well placed in the costodiaphragmatic angle has been so consistent that at the present time a good prognosis is given under these circumstances without regard to the position of the apex. Or to put it another way, if there is available lung surface to fill out against the chest wall no plastic operation is contemplated. On the other hand, if the surface of the lung has bowed out to its fullest extent without being able to fill the gap, a plastic operation is held to be desirable. Additional experience may well modify this view, but at present it is found to be an excellent working hypothesis.

The application of this hypothesis to the operation for acute empyema is of course most important. It is impossible in most instances to determine before operation the size and shape of the empyema cavity as well as the position and degree of freedom of the lung. If then, the lung in the majority of cases is already adherent in a favorable position, no such operation as that advised by Lilienthal (rib separation by a long incision with incision and separation of the limiting fibrin membrane covering the lung) should be necessary as a routine. The operation might then be reserved until it is demonstrated, by clinical and Röntgen examination after preliminary drainage, that the lung is held in a position unfavorable to expansion.

A study of operation notes and of Röntgen plates taken early after operation shows that of 26 operative cases: In 18 the lower outer angle of the lung was adherent well out in the costodiaphragmatic angle. In 1 the lung was collapsed and adherent (it was freed and recovery followed). In 4 the lung was free and expanded or free and collapsed. In 3 the relations of the lung were not noted.

It has been shown, then, in this series, that in two-thirds of the cases the lower angle was well placed and that there was ample lung surface available for expansion. These cases have made complete recoveries under simple rib resection (novocaine), and while I do not doubt that removal of the infected fibrin membrane might have hastened convalescence I should suppose that the Lilienthal operation, as carried out by most surgeons under average anæsthesia, would have led to a higher mortality (see results). Even in the hands of Lilienthal [6] the deaths resulting from the radical operation have totalled 27 per cent. in 44 cases as contrasted with a mortality of 16 to 18 per cent. in 45 patients upon whom a local drainage operation (with or without rib resection) alone was performed. All patients, however, who have recovered after the radical procedure have left the hospital entirely healed and without thoracic deformity, a most creditable showing.

In instances of complete collapse of the lung with adherence in unfavorable position (less than 4 per cent., or one case in this series) the Lilienthal operation should be of distinct advantage, but I can see no reason even then for making it a routine initial proceeding. Moreover, many huge empyema cavities allow at operation no clear indication of the actual position of the lung. There have been several cases (as, for instance, Case II) in this series in which the lung appeared to be completely collapsed and buried behind the usual shaggy yellow pus and fibrin coat. Yet inspection and Röntgen studies made within a week of operation showed that the lung had lain from the first flattened out upon the diaphragm, well out into the costodiaphragmatic angle, and that already it had nearly filled the chest.

I should plead, then, for more careful study of the empyema cavity before (if possible), during, and after the original drainage operation with the idea of adopting at the earliest favorable moment the particular procedure, if any, which is held to be essential to healing. Having this in mind, the original operation would properly consist in rib resection under a local anæsthetic, as the safest life-saving measure.

There follow the results of operation for acute and chronic empyema for the period January, 1913, to July, 1917.

There have been 26 cases of acute empyema. Of these, 3 died soon after operation, a mortality of 11.5 per cent.†

Of those dying after operation one showed before operation a fibrillat-

† The number of cases here followed is too small, of course, to furnish figures of much value, even though it covers unselected cases in four years of hospital life. The truth of this statement is borne out by the much higher mortality of the streptococcus empyemata of this present winter (1917–1918).

ing heart and died the day after operation; one died some months later of gangrene of the lung though the empyema cavity was well drained and nearly obliterated; and the third, a neglected case of eight weeks' standing, died suddenly on the day following operation while making an apparently good recovery (cause of death unknown).

Of the surviving 23, 19 have been seen or heard from recently and are well (73 per cent. of all acute empyema cases).

Of the above 19, 3 have required secondary operations, but are now well.

Of the 23 who left the hospital apparently on the road to recovery, 1 is still under treatment. The other three showed granulating wounds and healed cavities when last seen in the Out-door Department, but cannot now be traced.

If the 3 untraced cases thought to be healed are included with the 19 known to be well, the percentage of complete recoveries would be 84.

There have been 8 cases of chronic empyema. Of these 1 is well. Two have died of embolism (cerebral or pulmonary). One has died of tuberculosis. Three are much improved and are able to work. One is still under treatment.

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TREATMENT OF PENETRATING GUNSHOT WOUNDS OF THE CHEST WITH HEMORRHAGE INTO THE PLEURA*

By Lucius W. Hotchkiss, M.D.
of New York

Hæmothorax is the most common result of a chest wound, pneumo-hæmothorax and pneumothorax are said to be very rare. Hæmothorax may be sterile, or it may be infected. Infection may occur as late as the second or third week, its onset being characterized by pain, dyspnœa, fever, etc. In a series of 450 cases observed by Bradford and Elliott,[1] infection was present in 117. It will readily be seen, then, that the only justification of the old conservative routine of surgical non-intervention lies in the fact that so many cases of shot wound of the chest remain uninfected.

From the third day to the third week death from hemorrhage, in the above series, was rare as a result of the chest wound. Septic infection of the hæmothorax was the most common cause of death and secondary hemorrhage was extremely rare. The bloody fluid in hæmothorax is defibrinated blood. In infected cases the pleural exudate is abundant and there are many polymorphonuclear leucocytes. Massive clotting is more common in infected cases.

In a considerable proportion of the infected war cases, there was gas formation which was usually very rapid. The gas may be free in the pleural cavity or *localized* above the fluid and below the non-collapsed portion of the lung. There is a difference of opinion as to the most frequent source of the hemorrhage in hæmothorax, though it is very probable that, in the majority of cases, the source is the injury to the lung. But there are some cases in which the bulk of the bleeding comes from an injured vessel in the chest wall.

The physical signs of hæmothorax are variable, but an important one is a high diaphragm on the affected side. The main problem in diagnosis, however, is to determine whether a hæmothorax is infected or not. Rapid pulse, pallor, sweating and collapse are common symptoms of the rapid spreading anaërobic infections. Microscopical and bacteriological examination of the fluid withdrawn will determine the presence or absence of infection. Sometimes, it is necessary to explore the chest at different levels. In sterile hæmothorax, if the amount of fluid is small, there is no need for special treatment. If the amount of fluid is large, aspiration at the end of the first week is advised. Aspiration with oxygen replacement is said to be better than simple aspiration, the patient being left with 200 to 500 c.c. of oxygen in the pleura, at a pressure somewhat above the normal pleural pressure. Free drainage is advised in all cases of infected hæmothorax. Recently the Carrel-Dakin technic has been applied with success.

* Read before the New York Surgical Society, March 27, 1918.

[1] Bradford, J. R.: Brit. Med. Jl., 1917, ii, 141.

I have to present two cases, which exemplify two different types of hæmothorax. One, with acute progressive and wellnigh fatal hemorrhage, which called for immediate operation, and another, which illustrates the so-called clotted hæmothorax with later infection, and delayed operation. The following is the report of the case of urgent hemorrhage with immediate operation which is abstracted from the *Transactions of the New York Surgical Society*, for 1903.

At a meeting of this Society on May 27, 1903, I presented a patient upon whom I had operated a month previously, April 28th, for shot wound of the right chest with severe primary hemorrhage into the pleura. He had been brought to the hospital fifteen minutes after his injury, in a condition of extreme shock. He was immediately put to bed and given a subcutaneous infusion of warm saline solution. Examination showed a contusion and abrasion about one inch long, over the right anterior superior spine of the ilium. A second bullet had passed through the upper third of the right forearm. The third bullet was embedded in the right chest, the wound of entrance being through the gladiolus of the sternum, one inch above the ensiform cartilage.

Within two hours after the patient's admission, a large hæmatoma had developed over the right side of the chest, in the region of the eighth rib. It measured 4 by 6 inches then, and slowly increased in size, its long diameter being parallel with the long axis of the ribs and its centre in the mid-axillary line. The patient complained of a feeling of oppression and difficulty in breathing. When seen by me, about two hours after his admission, he was still in a condition of some shock but the hemorrhage had apparently ceased and he was slowly improving under treatment. A little later, he vomited some blood. About four hours later his condition was such that it was deemed wise to operate.

From the situation of the wound and its direction, it seemed probable that the abdominal cavity might have been invaded and accordingly an exploratory laparotomy was done under gas-ether anæsthesia. An incision 2½ inches long was made in the median line 2 inches below the ensiform. There was no free blood in the peritoneal cavity, the stomach and intestines were moderately distended with gas. The cardiac end of the stomach was normal in appearance, but the pyloric end was congested. There was no perforation of stomach or intestine. This fact determined, the abdominal wound was closed and attention turned to the chest.

An incision 7 inches long was made along the eighth rib, through the large hæmatoma which had developed, and a large amount of clots liberated. Two inches of the seventh and about four inches of the eighth rib were resected in the mid-axillary region. The eighth rib had been shattered and perforated by a bullet of thirty-eight calibre. The pleural cavity was opened and a large amount of fluid blood and clots was evacuated. The hemorrhage from the hole in the lung which was inspected had apparently ceased. The lower and middle lobes of the collapsed lung could be plainly seen and felt. There was also noted an abraded area over the dome of the diaphragm, evi-

dently made by the bullet. After washing out the cavity with hot saline solution the lower edge of the partly collapsed lung was sutured to the parietal pleura at the posterior superior margin of the operation wound and the posterior portion of the incision was closed without drainage. The anterior third of the wound was not sutured, but lightly packed with sterile gauze which did not extend into the pleural cavity. The outer dressings only were changed daily, on the three days following. They were lightly stained with an orange colored discharge. When the packing was withdrawn on the third day, the opening into the pleura was evidenced by the sucking in of air. Two days later, however, it had apparently entirely closed off by wound contraction and the lung expansion and it never reopened. The wound granulated rapidly from the bottom, the rest of the incision healing by primary union. Further recovery was uneventful except for marked abdominal distention and some vomiting during the first forty-eight hours. He was discharged as cured, May 19, 1903, twenty-one days after his injury.

The lung expansion was apparently normal and the bullet could be felt near the inner edge of the right scapula, but gave him no trouble.

The treatment of this case, fifteen years ago, in the light of recent war experience, was proper and conservative and the result certainly justified it.

Gunshot wound of the left lung with clotted hæmothorax later becoming infected. Late primary drainage—later resection and partial decortication of the lung. Recovery.

On June 9, 1917, I saw in consultation, in a distant city, a case of gunshot wound of the left chest which had been sustained about two weeks previously. The patient, a woman about forty-two, was shot at close range by a revolver bullet which entered the front of the left chest between the second and third ribs below the middle of the clavicle, passing obliquely from above downward and backward until it lodged under the skin over the tenth dorsal vertebra, where it had been removed some days before.

The patient's condition at the time of my visit was not good, she was running an irregular temperature, between 100° and 102°, she looked very pale and had greatly embarrassed respiration and a rapid pulse. There was flatness over the whole side of the chest and the radiograph showed the entire left side of the chest to be cloudy, with all the normal lung markings obliterated. Aspiration yielded a blood-stained fluid. Her condition was not improving under conservative treatment and the question of operation was put cleanly up to the surgeon. Drainage seemed to me imperative on account of her condition and the probability of infection. The patient was unable to take a general anæsthetic on account of her oppressed breathing, and under local anæsthesia with one-half per cent. cocaine an incision was made near the posterior axillary line between the sixth and seventh ribs, and the pleura opened. A rubber tube was inserted and a large amount of bloody fluid with a slightly perceptible odor but no clots was evacuated. The

little operation, which was regarded as merely a preliminary to a later and wider drainage, gave great relief. The patient was left in the hands of her physician and not seen again until after the lapse of twelve days. At the second visit, the attending physician reported considerable relief from the operation, but the elevated temperature still persisted and the drainage was not satisfactory, the tube being evidently blocked by clots. As the patient's condition had been much improved by the relief of pressure on the lung, it was deemed safe at this time to give a general anæsthetic. Accordingly, under gas-ether anæsthesia, the incision was extended backward and a portion of the seventh and eighth ribs removed and a reasonably wide opening into the pleura made. The cavity was found filled with soft clots which were washed out with warm saline solution. There was no fresh bleeding and, as there was no gross pus present, the wound was partly closed and drainage provided by loose sterile gauze packing in the wound. Much relief to breathing followed this operation and the patient was left in good condition. Following this the patient improved, but the drainage was still not satisfactory, so that a tube had to be inserted, and this would become obstructed from time to time with clots. Accordingly, about one week later, June 28th, the patient was sent to New York and placed under my care at the Roosevelt Hospital.

The wound was dressed soon after her arrival at the hospital and the discharge was free and purulent. She had stood the long journey well. Her temperature still remained elevated and she appeared distinctly septic. She was dressed daily, and about July 1st a long tube was inserted and the chest was washed out with saline solution, which seemed to improve the condition very much, as her temperature fell and she was able in a day or two to get up in a chair and to use the blow bottle to improve the expansion of the lung. During the following few days large fibrinous clots were washed out from time to time, always with relief, so that the temperature gradually fell to about normal and the discharge decreased and became somewhat thinner and the lung expansion continued to improve. By July 21st the drainage opening had so constracted that unless a long tube were used so as to pass above the arch of the diaphragm, it was ineffectual. By August 1st the temperature remained flat for five days and the discharge was thinner and much reduced in amount. Washing out occasionally through a larger tube was done, but the clots seem mostly to have disappeared. On August 6th the drain tube was left out experimentally for a test. Temperature remained flat for four days, the wound granulated in, and there was no discharge. Then there began to be slight rise, a little headache and sleepiness and finally, on August 11th, there was a rise of temperature to 102° and during the night the wound broke open and flooded the bed with pus. The drainage tube was then reinserted and the exercises with the blow bottle continued. The patient's general condition was all the time improving and she got up and moved about the hospital. On August 20th the chest cavity was injected with barium mixture through the drainage sinus and a radiograph was made to show the extent and limits of the space. Con-

siderable reaction followed, as the barium obstructed the drainage more or less for several days and had to be washed out. The limits of the empyema cavity as shown by X-ray extended from the fourth to the ninth rib.

For several days in the latter part of August, the discharge was quite thin and the tube would be left out for a day or two and then reinserted. By September 3rd, the expansion had so far improved under the exercise of the blow bottle that the patient felt quite encouraged. By the middle of September the discharge was thin, but any attempt to allow healing was followed by retention.

It seemed necessary, therefore, to resort to further operative measures if the space were to be obliterated and the adherent lung freed.

On September 20th the patient was taken to the operating room for the third time and, after the usual preparation and under gas-ether anæsthesia, the original incision over the eighth rib was extended laterally and a long vertical incision was made from its posterior extremity upward behind the scapula through the muscles, allowing the scapula to be well retracted and the field well exposed. The lower ribs, eighth and ninth, were resected to the extent of several inches, and through this opening the length, shape, and height of the cavity was determined. The cavity was found to be a triangular-pyramidal space extending upward and backward and narrowing as it went up and terminating behind the fourth rib and extending downward to the level of the tenth rib, gradually broadening out toward the base. The lung covered with much thickened pleura was adherent to the parietal pleura at the lateral boundaries of the cavity. A short section of the fourth rib was resected and gradually longer pieces of the lower ribs until the ninth was reached, which was excised up to the limits of the base of the cavity. The thickened parietal pleura was also excised, which gave a perfect exposure of the surface of the lung to be decorticated. The pleura covering the bound-down portion of the lung was then incised and flaps turned back by blunt dissection, which allowed the lung to expand and fill the space. This step of the operation was materially helped by converting the anæsthesia apparatus into a positive pressure machine which blew out the lung nicely. After the broad decortication, the hemorrhage, which was not excessive, was controlled, and the edges of the incision brought together by layer sutures. As the lower end of the wound had been the site of the old sinus it was not possible to thoroughly disinfect it. This part of the wound was not closed by suture, but the edges came fairly well together after the old granulations had been thoroughly curetted away. At the close of the operation the lung was once more blown up by positive pressure and the remaining open end of the wound was covered with a piece of sterile adhesive plaster and the dressing applied.

The operation was long and difficult, but the patient bore it well and showed only moderate shock at the closure. She soon rallied, and, after the first forty-eight hours, gave us no anxiety.

The wound became infected both at the lower and upper end, but the removal of a few sutures and release of tension was followed by

healing throughout its greater part by primary union. Drainage had to be instituted for several days at the lower angle on account of retention of bloody fluid and, later, of pus. But the wound after several weeks healed satisfactorily throughout and the sinus has remained completely closed. Good lung expansion has been obtained and the patient is happily at work and free from symptoms.

The final result, obtained after many weeks, has been very satisfactory to both patient and surgeon and corresponds in large degree with similar results obtained in several cases of empyema from other causes in which decortication of the lung has been followed by satisfactory expansion and complete closure of the sinus. Had it been possible at the primary operation to have secured through a more extensive incision thorough evacuation of all the clots, the history of the case might have been different, but the conditions were not favorable to such a procedure.

With the progress of the great war the history of the surgical treatment of penetrating wounds of the chest is being largely rewritten and an examination of the literature of the subject shows a marked tendency toward radical early operative interference in selected cases based upon the modern method of wound prophylaxis against infection, performed at the earliest possible hour and followed in appropriate cases by closure of the wound.

A brief résumé of some of the work that has been done in the service of the British and French armies during the past two years is added. The literature already large is constantly growing and is of the greatest importance and interest.

In an analysis of 170 cases of chest wounds seen by him at a base hospital in France during the first two years of the war, ELLIOTT[1] groups them as follows:

1. Sterile hæmothorax, 89. 2. Septic effusion, 64. 3. Clotted hæmothorax later septic, 3. 4. Sterile pneumothorax, 6. 5. Severe laceration of the lung, 2. 6. No effusion, 6.

The chief practical points of this valuable paper, as summarized elsewhere, are, first, that a sterile hæmothorax of moderate extent, *i.e.*, about thirty ounces, will recover as rapidly by natural absorption as by aspiration.

Second, the retention of foreign bodies in the chest in aseptic cases appears not to cripple the bearer for further military service.

Third, cases of infected hæmothorax that have been drained and then transferred to England generally recover rapidly and completely. There were no deaths in these cases and later operation was rarely needed. Of these more than one-half could return to duty.

Fourth, the late mortality of chest wounds is practically *nil* in England, and only about 5 per cent. in the lines of communication in France. But in the region of the armies it is higher than at first supposed—that is to say, about 10 per cent. to 15 per cent. may die from the severity of the injury, and about 10 per cent. later at the casualty clearing stations from sepsis.

Fifth, among the cases which develop sepsis within the chest the mortality is very high, rising to nearly 50 per cent. by the old system of rib resection and drainage.

[1] Lancet, Lond., 1917, 193, p. 371.

Sixth, the old conservative routine of surgical non-intervention except by late drainage finds its justification only in the recovery of those cases of gunshot wounds of the chest which remain non-infected, about 75 per cent. The high mortality in those which develop sepsis demands a wider practice of new prophylactic method of cleansing operations performed at an early hour in a carefully chosen group of cases.

COMBIER and HERTZ,[3] in a recent paper on the "Early Treatment of Septic Pleural Effusions Consecutive to Chest Wounds," advise non-interference in wounds showing neither fracture nor effusion. If there is fracture of the rib or scapula they reduce the fracture and close. A small foreign body is left. If of considerable size, and easily accessible, it is extracted immediately. In other cases secondary extraction is preferred. If there is pleural effusion which examination shows to be septic, a low incision is made, under local anæsthesia, in the posterior axillary line, and a portion of the ninth rib resected. Foreign bodies in the affected area are extracted. The pleura is then disinfected by means of an intermittent irrigation of Dakin's fluid.

Of 15 cases so treated, 12 recovered, 11 from pleural abscesses, and 1 from a subphrenic abscess. In 3 cases there was a later reinfection of the operative wound which had to be redisinfected and closed; complete recovery. They advise great prudence is deciding upon the time of suture, for it is always necessary to wait until 2 or 3 successive examinations of the wound show the permanency of its disinfection before closing.

Radioscopy in recovered chronic cases shows the costophrenic angle adherent and immobile, the diaphragm being raised even in forced expiration, showing that the lung does not penetrate the costophrenic sinus. In early operated cases, however, the thorax preserves its form and almost normal limits, and radioscopy shows a normal permeability of the lung tissue which shows that the value of the recovery appears to be very much greater in cases where early operation is done.

V. PAUCHET[4] says that 30 per cent. with chest wounds die at the first aid stations of asphyxia or hemorrhage and 20 per cent. in the ambulance, and a few later in the interior. If those that die on the field are added it can be said that the majority of chest wounds in this war are fatal. He divides the treatment into: (1) the immediate, and (2) late, the first indication being to combat shock—infusion, transfusion, etc. Open wounds often call for immediate intervention; closed wounds for rest and watching. In open wounds he removes the fractured rib, cleans out the wound, removing the projectile if easily found.

A. L. LOCKWOOD and J. A. NIXON,[5] in an article entitled "Treatment of Septic Hæmothorax and Empyema," sum up their experience as follows:

Explore the wound under general anæsthesia, fractured portions of rib to be resected, and wound sewn up if the condition allows. The pleural cavity is then drained in the usual fashion, resecting about 3½ inches of rib as far forward and as low as possible; that is, generally the eighth rib in mid-axillary or anterior axillary line. Through this opening explore the cavity, remove an easily accessible foreign body from cavity or surface of the lung. Blood clots and fibrin should be swabbed off as fast as possible, and any septa-forming loculi should be broken down. The cavity is next washed out with a warm mixture of H_2O_2 and eusol or Dakin's fluid. A large rubber with a ¼-inch inside diameter and with a large lateral opening ¼-inch from the end is so inserted that the end lies in the lowest part of the pleural sac costovertebral recess. The wound is loosely closed, no attempt being made to secure air-tight closure around the tube.

When the patient has recovered the size of the cavity is estimated by filling it carefully, but generally incompletely, with Dakin's fluid, and then emptying it. After

[3] Bull. et mém. Soc. de chir., 1917, liii, p. 678.
[4] Presse Méd., 1917.
[5] British Medical Journal, February 2, 1918.

this, about every four hours, it is filled to about ⅓ capacity; then, after two hours, another long tube is attached to the tube in the chest and siphoned off, the patient meanwhile lying upon his sound side with the drain uppermost. He is instructed to pant or cough lightly so as to bathe all parts with the Dakin's fluid. In this way, every two hours, the cavity contains considerable fluid and then is empty for two hours. While full the patient lies on his sound side without raising his shoulders, so as to prevent the escape of fluid. Later he lies on the injured side. The tube is removed and sterilized once daily, and the cavity is washed out. The principles underlying operation in these cases are: excision of the wounds in the chest wall, wiping out of the pleural cavity if the lung has collapsed, and hæmothorax is present. Search for foreign bodies and remove the fragments if practical, finally, to close the wound completely. The aim of the operation is prophylaxis against sepsis, if it fails secondary drainage may be necessary.

J. E. Roberts and J. G. Craig[6] report 199 cases. Of these 108 were evacuated without operation, 124 died without operation, 67 were operated upon. Of these 67 apparently forlorn hopes, 34 recovered and were sent to the base. Of the 33 fatal cases, 16 had other gross lesions which were more directly responsible for their death than the operation. Excluding these, the rate of mortality in the 51 remaining cases was 33⅓ per cent. recoveries. The principles followed involved early operation, free excision of infected tissues, removal of the foreign body, and cleaning the pleural cavity and wound of the lung, followed, when possible, by accurate suture without drainage. No cases were drained unless the chest wall could not be closed, owing to the condition of the patient, or in cases where infection of the lung and pleura as distinguished from the contents could be definitely established.

The most frequent cause of death in chest cases with no other injuries was septic bronchopneumonia of the uninjured lung.

Duval urges immediate operation in severe primary hemorrhage in penetrating chest wounds. Hartmann remains skeptical, finding from inquiry at several ambulances where thoracotomy is not done the mortality varies from 12.7 to 18 per cent., which is the same as Duval reports with operation. However, in Hartmann's cases no report is given of cases dying from hemorrhage.

Duval in the discussion brought forward some additional cases to those included in his first report, making his mortality 32.1 per cent., with recoveries in 67.9 per cent., and he reiterates his opinion that in all severe hemorrhages thoracotomy with suture of the lung saves two-thirds of the patients.

J. Anderson[7] classifies his severe cases into two groups from the point of view of prognosis: 1. Entrance and exit bullet wounds, and wounds caused by small fragments of high explosive-missiles. These cases do well with expectant treatment and may be aspirated or operated as occasion arises. 2. Wounds caused by large irregular fragments of high explosive shell which has lodged in the thorax and almost always associated with carried-in portions of clothing and infection, and open "sucking wounds" of the chest wall. If these cases are treated expectantly only a small percentage ever reach the base hospital and many of those which do die of wound complications. In this group also he includes tangential wounds of the thorax which enfilade the ribs and drive portions of bone into the pleura and lungs and those entrance and exit wounds in which the exit wound is "explosive" in character. The prognosis in these is usually not so severe, but an unduly large number develop infection unless the chest wall is treated energetically. Cases of the second group have generally died at the Casualty Clearing Stations of sepsis and exhaustion. Many could probably be saved by immediate operation on the lines adopted for other wounds.

[6] Brit. Med., 1917, "Surgical Treatment of Severe War Wounds of the Chest."

[7] Brit. Med., 1917, "Surgical Treatment of Severe Penetrating Wounds of the Chest at a Casualty Clearing Station."

THE RELATION OF GASTRIC ULCER TO CANCER

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The relation of peptic ulcer to cancer of the stomach is a matter of first importance in the pathology of this organ, and, since gastric cancer is the most frequent form of malignant disease, it is a matter of considerable economic importance. If a high proportion of peptic ulcers, 50 per cent., become transferred into cancer, then the excision of two gastric ulcers prevents the development of one cancer, which is practically a fatal condition. Moreover, if gastric ulcer is a strongly predisposing condition to cancer, since it usually gives pronounced symptoms before reaching an inoperable stage of malignant change, ulcerocancer is the only type of gastric carcinoma which offers a favorable prognosis. On the other hand, if ulcers seldom result in cancer, it is unwise to spread the belief that by excising ulcers we are seriously attacking the problem of gastric carcinoma.

On the relation of ulcer to cancer, there are the widest variations of opinion. Rokitansky, in 1840, recognized that cancer might develop from ulcer. Dietrich, 1848, among 160 cancers found 6 developing near ulcers, and two in which the carcinoma was limited to portions of ulcers. Lebert, 1878, calculated that 9 per cent. of cancers arise from ulcers, while Zenker, 1882, went so far as to say that all gastric cancers are secondary to some form of ulceration. In 1890, Hauser described five cases of cancer of characteristic anatomical form following ulcer and at the same time 33 cases of other types. He pointed out the frequent persistence of free HCl in these cases. G. Futterer, 1902, concluded that ulcers in the pyloric region frequently give rise to cancer, especially in those portions of the ulcer most exposed to irritation. Mayo-Robson is quoted as finding a history suggestive of ulcer in 59.3 per cent. of his cases of gastric cancer, but he reports (1904) only one case in which a carcinomatous change in an ulcer was actually demonstrated. Payr distinguishes between simple and callous ulcers and by serial sections finds cancerous changes in 26 per cent. of the latter. Kuttner found them by serial sections in 40 per cent. of 30 cases. The Mayo clinic reports that 71 per cent. of their gastric cancers were associated with ulcer, and 68 per cent. of ulcers were complicated by carcinoma.

On the other hand, more recently, Kuttner expresses himself in quite a different way, stating explicitly that "transformation of ulcer into cancer we have not observed." The majority of callous ulcers he regards as originally cancerous and says that only exact pathological study can determine this question. Duplant (1898) described eight supposed cancerous ulcers and concluded that they were all originally cancers. He supported with numerous arguments the view that all previous cases of ulcerocancer were

misinterpreted, and concludes that cancer never develops on peptic ulcer. Hirschfeld places the proportion of ulcers that become cancerous at 5 to 6 per cent., and he summarizes clinical and statistical data indicating that the proportion is small. Among 500 ulcers reported by Stall, Greenfeld and Berthold, only 13 showed cancer and in three of these the cancer was not connected with the ulcer. Boekelmann collects a series of estimates varying from 3 to 50 per cent.

From the surgical side, the following proportions of cancerous transformation of ulcers are reported: Rubritius, 8 per cent.; Mayer, 1.9 per cent.; Busch, 2 per cent.; Spriggs, 2.1 per cent.; Bamberger, 2 per cent. in 1589 cases; Drummond, none in 72 cases long observed. Borrmann reports that among 63 gastric resections by Mikulicz for cancer none showed an origin from ulcer. In France opinions are widely at variance. Moutier in 35 cases from operation and autopsy found 19 simple ulcers, 15 distinctly cancerous, and 1 cancerous duodenal ulcer.

Thus, among acceptable authorities it is possible to choose between 2 and 68 per cent. of ulcers becoming cancerous, and between none and 71 per cent. as representing the proportion of gastric cancers that arise from ulcers. It is therefore evident that the criteria upon which one may assert that an ulcer is cancerous or that a cancer has arisen from peptic ulcer have never been clearly established or have not been respected.

It is the object of this paper to offer a contribution in this direction.

The evidence bearing on the relation of cancer to ulcer may be derived from several sources: statistical, clinical, gross anatomical, and microscopical.

Statistical.—The statistical evidence relates to the sex and age of the patient with simple ulcer and cancer, to the locations of the lesions, to the fate of ulcers under treatment, and to the occurrence of healed ulcers.

Hirschfeld has shown that in Berlin and Hamburg, ulcer is more than twice as frequent as in Zurich, Munich and Vienna (7 per cent. *vs.* 3 per cent.) while gastric cancer is rather less common. Yet autopsies show the same rates for gastric cancer in both Berlin and Vienna (3.3 to 3.5 per cent.). Gastric ulcer may have been a more popular diagnosis in the Berlin hospitals than in Vienna. These comparisons do not appear to be very impressive. Gastric ulcer in these cities was about four times as frequent in women as in men, but gastric cancer about equally or more frequent in men.

Williams finds in England a cancer mortality from gastric cancer among males of 21.4 per cent., females 13.2 per cent., but he found 60 gastric ulcers among 32,505 male patients and 117 among 28,175 females. The sex divergence is therefore rather striking. Bulstrode reports that in the London Hospital 402 cases of gastric ulcer were in females, 98 in males. Fiedler in 2200 bodies found ulcers or scars in 20 per cent. of female, 1.5 per cent. of male bodies. On the other hand, not a few recent observers have found ulcer quite as frequent in men as in women. Since the older view was rather substantially supported, one must conclude that some recent observers have encountered a selected material, or that they have not carefully

excluded ulcerating cancers, or else that the proportions have actually changed. It seems at present difficult to state whether there is a great preponderance of ulcers in women.

Half the gastric ulcers occur between the ages of twenty and thirty years, and nearly all before thirty-eight, while most cancers occur in the decade of fifty to sixty years (Williams). Yet the age incidence is not always so uniform. Riegel shows that the maximum frequency for ulcers is between twenty and thirty years for women (62 cases), and between forty and fifty for men (36 cases), while isolated cases occur in advanced years. Greenough and Joslin in 187 cases found gastric ulcer five times as often in females as in males. The average in men was thirty-seven years, in women twenty-seven years. Yet Hauser's 5 cancers which were rather clear sequels of ulcer occurred between the years fifty-five and eighty-three. It is possible that the transformation of ulcer into cancer is limited chiefly to subjects well advanced in years.

The seats of election of cancer and ulcer do not favor the frequent origin of one from the other. The commonest seat of ulcer is the lesser curvature (36.3 per cent., Welch, Fenwick), whereas only 12 per cent. of cancers occur in this situation (Brinton, Welch). The commonest seat of gastric cancer is the pylorus, 60 per cent. of 4574 cases collected by Williams occurring there, while only 12 per cent. of Welch's 793 cases of gastric ulcer were thus located.

Williams regards the statistical evidence as incompatible with the frequent origin of cancer from ulcer, but it does not preclude the possibility that it occurs in a considerable number of cases. The theory of the cancerous transformation of peptic ulcer would be more acceptable if there were parallels in other organs, but in the lip, tongue, tonsil, œsophagus, rectum, larynx, cervix uteri, and in X-ray dermatitis there is first carcinoma and then ulceration. In the few instances where carcinoma follows ulcer, the malignant process develops as a rule only after many years, as in varicose ulcers of the leg. Lupus carcinoma never appears before the fifth and usually toward the thirtieth year of the disease and in the scar tissue. The cervical erosion is often associated with carcinoma, but these lesions are not originally ulcers, but rather extrusions of the mucosa which are long the seat of irritation and glandular overgrowth. On the other hand, the peptic ulcer is an exceptional condition and may be followed by exceptional results.

Clinical Evidence.—Since the development of cancer in a peptic ulcer must require considerable time, a history of gastric ulcer should be available in all cases so interpreted. Although gastric ulcer may occasionally fail to give symptoms, this situation must be extremely rare in any long continued case, and so long as the question is open to debate it would seem that no case should be accepted as an ulcerocarcinoma unless a long history of peptic ulcer is provided. The gastric ulcers that fail to give symptoms and furnish the healed scars found at autopsy are usually small or superficial. Latent cases of fully developed peptic ulcer are very rare.

Mayo-Robson is said to have found a history suggestive of ulcer in 60 per cent. of his cases of cancer, but suggestive symptoms are not sufficient. More convincing is the very definite report of pain, vomiting, and hæmatemesis of ten years' duration in one of Hauser's cases. Bamberger reports a history of recurrent ulcer for thirty-two years before death from ulcerocancer, and Mayo-Robson one of twenty-one years' duration. Greenough and Joslin observed a characteristic history of ulcer for two years before death from a secondary cancer. Riegel states that he is able to recognize clinically the cases of ulcerocarcinoma. They first show a long period of hyperacidity and symptoms of ulcer, then a tumor appears, the cachexia changes, and free acid diminishes or disappears. Hauser claimed that the long persistence of free HCl indicated an origin of the cancer from ulcer, but this feature is not invariable. Lockwood found a history of ulcer suggestive in 7 per cent., definite in 3 per cent., of 174 cases of gastric cancer.

An important phase of the clinical evidence relates to the fate of ulcers long observed and treated, which shows that while ulcer is permanently cured by medical measures in only about 40 per cent., it very rarely develops into cancer while under observation. Greenough and Joslin followed for five years 114 cases of ulcer treated medically. Of these 41 recurred, 27 died, 4 from unknown causes, but only 1 from the subsequent development of cancer. Hemmeter, who is one of the few authors who have adequately considered the complexities of the diagnosis, observed only three cases of cancer developing in the course of 232 peptic ulcers.

The results of gastro-enterostomy for ulcer reveal a small percentage of recurrences in the form of carcinoma (Galpern Lit.). In 1025 gastro-enterostomies for ulcer, traced for some time, Bamberg collected 22 cases developing cancer, 2.1 per cent. In 152 ulcers treated by resection, cancer developed in 1.9 per cent. Since the carcinoma usually developed within two years of the gastro-enterostomy, there is some reason to assume that some of the ulcers were originally cancerous. Gressot from an elaborate study of the literature concludes that ulcers become cancerous in 2.3 per cent. of cases treated by gastro-enterostomy. Billeter observed the course of 116 cases of ulcer treated by gastro-enterostomy. Eighty-seven patients were well after four to twenty-six years and only one developed cancer. Von Eiselsberg reports that of 269 cases of ulcer treated by gastro-enterostomy, 13 died from cancer (5 per cent.), while among 41 cases in which the ulcer was excised 2 died from cancer (also 5 per cent.). Sherren saw no cases develop cancer among 200 gastro-enterostomies for ulcer.

From the clinical evidence it may be concluded that a great number of ulcers have been treated medically for some years without developing cancer, that among the many ulcers so treated which persist or recur not more than 2 per cent. develop cancer and some of these may have been originally cancerous; that the number of cases developing cancer from ulcer after gastro-enterostomy is not appreciably larger than after resection of the ulcer; that a diagnosis of cancer following ulcer to be acceptable should carry

with it a previous history of ulcer; that this history covers a period of ten to thirty years in certain well attested cases, while in less satisfactory but possibly genuine cases the history of ulcer covers only two years.

Gross Anatomy.—The gross anatomy of cancer engrafted upon ulcer is usually characteristic, and hence if the case is to be accepted as such, this characteristic appearance should be demanded. On the other hand, it has repeatedly been shown that grossly typical peptic ulcers may form on a mucosa which is the seat of carcinoma. Failure to realize this fact has often led to the excision of ulcers under the impression that they were benign. A microscopic study in every case is called for.

Hauser clearly depicts the rather specific appearance of cancer grafted upon ulcer (Fig. 1). The deep, sharply cut excavation, overhanging proximal edge, firm fibrous base, and often the extension of the cicatrix to surrounding organs are satisfactory evidences of the long existence of a typical peptic ulcer. The carcinoma has usually appeared at one or more points, usually distal, sometimes becoming fused, and causing induration and fixation of the edge. Outlying islands of polypoid adenoma or adenocarcinoma are not infrequently observed. Menetrier states that carcinoma develops on ulcer only after a preliminary stage of polypoid adenomatoid growth.

The necessity of insisting upon a dense indurated base free from cancer seems to me essential. A. Schmidt finds it impossible to conceive how large flat ulcers, 3 to 4 cm. in diameter with extensive cancerous infiltration of the periphery, can be derived from the malignant transformation of an ulcer. The opposite relation seems to him more probable.

That an original cancer may be stripped of epithelial tissue over a central area and the base converted into dense cicatricial tissue resembling peptic ulcer is shown by Verse, in the report of his case No. 34.

The early stages of many carcinomas of the stomach reveal the important rôle of ulceration in the course of these lesions. Verse has described 12 very early carcinomas of the stomach. They consisted of circumscribed thickenings of the mucosa, 1 to 2 cm. in diameter, in which the glands presented the changes of adenocarcinoma or fully developed carcinoma. In some, the surface was unbroken, but the stroma was infiltrated by polynuclear leucocytes. I have studied such a lesion covering an area of 2 cm. in the cardiac region. Usually ulceration had become established with more or less complete excavation of the central portion. These early and rarely observed lesions reveal the close connection between ulceration and cancerous proliferation in carcinoma of the stomach and they emphasize the necessity of great caution in assuming that an ulcerating and carcinomatous process is anything else than an ulcerating cancer. Especially in the pyloric region where mechanical erosion is constantly at work, early and sometimes deep ulceration may be expected as a natural sequence in the growth of carcinoma.

In certain cases of peptic ulcer followed by carcinoma the latter process has appeared to be disconnected from the former (Hauser, Verse, Galpern). This occurrence has been sufficiently frequent, as after excision of ulcers,

to lead to the conclusion that when carcinoma does follow ulcer the relation may be accidental. Galpern and Bamberger state that the stomach with peptic ulcer is as likely to become cancerous as the normal stomach and no more. Yet this conclusion ignores the undoubted development of cancer in the inflamed edges of certain ulcers.

From the anatomical data one may conclude that the gross appearance of cancer grafted on ulcer is usually characteristic; that this evidence is the most direct and convincing in regard to the relation of the two processes and should be demanded in acceptable cases; that ulcerating cancers may closely simulate peptic ulcers with secondary malignant changes; and that cancer and ulcer may occur independently in the same stomach.

Microscopical Evidence.—The development of carcinoma in the edges of chronic ulcers has been minutely described by Hauser, Verse, Menetrier, Wilson and McCarthy and others. In this field it is necessary to emphasize the difficulty of recognizing all the structural variations which carcinoma may exhibit. When one compares the fading remnants of carcinoma cells in the leather-bottle stomach (linitis plastica) with the bulky masses of adenocarcinoma, and contrasts these in turn with the diffuse round-cell carcinomas and the curious forms arising in wide areas of glands with intact membrana propria, one realizes that in carcinoma of the stomach there are unusual hazards in histological diagnosis. Perhaps the active movements of the pyloric antrum account for some of these structural peculiarities. When such an experienced observer as Krompecher, after years of study of pyloric stenosis, is forced to change his opinion and to accept these lesions as carcinomas which he had long failed to recognize, it becomes apparent that this is no field for hasty interpretation.

In Hauser's cases the edges of the ulcers were markedly hypertrophic, the carcinomatous changes were most marked at the line of ulceration and extended with diminishing intensity for a distance of ½ to 1 cm. over the outlying mucosa, the infiltration involved the peripheral submucosa and the muscularis, while the indurated base of the ulcer was free from infiltration. The various stages of transformation of the normal into carcinomatous glands were traced in detail, ending usually in an adenocarcinomatous structure. Lesions presenting these features and this series of changes in portions only of the edges of indurated ulcers must be accepted as satisfactory examples of the development of carcinoma on peptic ulcer. I do not find, however, that all authors have observed these criteria in the diagnosis of ulcerocarcinoma. Verse describes three typical cases and then ventures with some hesitation to include a fourth, a broad ulcer in a woman of twenty-eight years in which projecting islands of carcinoma of rather diffuse type occurred over the base of the ulcer. I cannot regard this lesion as anything else than an ulcerating cancer. It would seem extremely unlikely that a secondary carcinoma can ever invade the indurated base of a peptic ulcer. These tissues are usually very dense and fibrous and when they are invaded by carcinoma it would be much safer to assume that the infiltration existed before the ulceration.

McCarthy evidently includes among the evidences of carcinoma a variety of inflammatory hyperplasias and misplacements of gastric glands some of which result from inflammation about the ulcer and at other times probably precede the formation of the ulcer. These changes may well be grouped in the class of precancerous processes. Yet it is one of the dangers of the dissemination of the doctrine of precancerous lesions that their presence may too readily be assumed to mean that carcinoma already exists or soon will appear, whereas there can be no certainty that any given precancerous lesion would, if undisturbed, go on to develop cancer. In the case of gastric ulcers Galpern's and Bamberger's observations on the fate of gastric ulcer after gastro-enterostomy seem to prove that these lesions seldom go on to produce cancer.

In my own material I have had much difficulty in deciding how to interpret some ulcerating and cancerous lesions. Certain conclusions, however, have been drawn from the study of material from autopsy and operation which bear upon the relation of cancer to ulcer.

(1) The great majority of ulcerating lesions of the stomach fall clearly in the classes of ulcerating cancers or simple peptic ulcers. The cancers are usually broad, widely and uniformly infiltrating, and the ulceration is merely an erosion or an irregular excavation beginning in the centre and extending over much of the surface. Pyloric cancers are especially prone to suffer excavation. The peptic ulcers are sharply cut, the edges flat but overhanging, the base is indurated and free from any signs of cancer. The surrounding mucosa shows much or little glandular overgrowth. This material does not support the view that peptic ulcer tends strongly to atypical glandular proliferation.

(2) With certain peptic ulcers a large part of the gastric mucosa is the seat of glandular hypertrophy with atypical changes in isolated glands and interstitial growth of connective tissue which causes some disarrangement of the glands. This condition is not secondary to the ulcer but may well predispose to ulcer. It may serve as a source of error in interpreting atypical overgrowth on the edges of ulcers (5584, 5715) (Fig. 2).

(3) Deep excavations may occur in portions of established carcinoma especially in the pyloric region where powerful muscular contractions tend to cause hernias of infiltrated and weakened muscular tissue. This condition appears clearly in three of my cases. In case 5296 the entire pyloric region for a length of 6 cm. is the seat of a broad, dense carcinoma of uniform texture. It is considerably excavated and at a point 2 cm. from pylorus the excavation descends abruptly in a cavity ½ cm. deep which lies upon pancreas. All portions of the ulcer, edges, base, and adjoining pancreas are uniformly infiltrated with large alveolar adenocarcinoma. Some would interpret this case as carcinoma grafted upon ulcer, but I am unable to conceive how carcinoma could have infiltrated so uniformly all portions of the base of this lesion if it arose on the edges of an ulcer and had to attack old dense connective tissue. This same type of adenocarcinoma covered the

mucosa uniformly for a distance of 3 cm. about the ulcer. There was no history of an old ulcer (Fig. 3).

In case 5099, a very similar gross lesion with deep central excavation proved to be a rapidly growing diffuse round-cell carcinoma. The tumor cells infiltrated the entire base of the ulcer, splitting up the muscular coat and invading the subserous fat and the pyloric lymph-nodes. This type of carcinoma is not readily derived from atypical proliferation on the edges of an ulcer (Fig. 4).

Case 8253, placed at my disposal by Doctor Elser of New York Hospital, is highly instructive, illustrating the formation of peptic ulcers on a diffuse carcinoma of the stomach. The patient, a male, fifty years, moderately alcoholic, enjoyed good health until four months before death, when he began to suffer from gastric disturbance soon followed by sharp pains after eating. He died after laparotomy. At autopsy there was extensive miliary carcinosis of peritoneum. The whole pyloric region of stomach showed moderate thickening of mucosa increasing toward the pyloric orifice, and this region was irregularly adherent. There were three typical peptic ulcers. One was a slit-like excavation at the pyloric orifice looking into the duodenum. The others lay on posterior surface 6 and 9 cm. from the pylorus. They measure 1½ cm. in long diameter, edges overhanging but not indurated, bases cleanly excavated and smooth, extending into muscularis. On microscopical examination the entire pyloric region was the seat of diffuse carcinoma infiltrating all coats. The bases of the ulcers were formed throughout by carcinoma tissue infiltrating the muscle. The remnants of glands on the edges showed no change (Figs. 5 and 6).

(4) Gastric digestion may strip a primary carcinoma down to the muscularis or deeper, leaving no trace of carcinoma over most of the base but only a peripheral ring of tumor tissue which is protected by the mucosa. This event is indicated in some of Verse's cases which ulcerated early and it appears in one of mine.

This case, 5397, presented the usual appearance of peptic ulcer of rather broad dimensions and was excised as such and at first passed the laboratory as simple ulcer. On section it was found that the entire ulcer was surrounded by a continuous narrow ring of carcinoma partly protected by the intact mucosa (Fig. 7). Glandular proliferation of the peripheral mucosa was missing, the tumor ending abruptly. The structural type was that observed in many early carcinomas, strongly atypical small alveolar adenocarcinoma. The lymph-nodes were not involved. The central two-thirds of the base was free from carcinoma. Wilensky and Thalhimer seem to have encountered a notable case in which all traces of an original carcinoma were completely excavated, leaving a simple peptic ulcer in the stomach wall, while the adjoining lymph-nodes were the seat of carcinoma.

(5) When the base of an ulcer is uniformly infiltrated with carcinoma, especially of diffuse or atypical small alveolar type, the condition is difficult to reconcile with an origin from the edges of the ulcer (Fig. 8). When

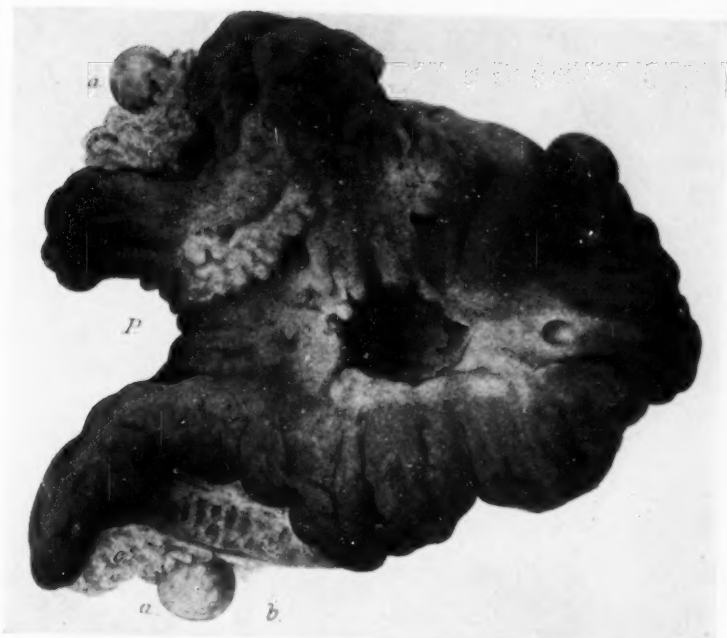

FIG. 1.—Hauser's drawing showing the gross anatomy of carcinoma grafted upon ulcer. Note the polypoid projections and the irregular distribution of the opaque carcinomatous tissue.

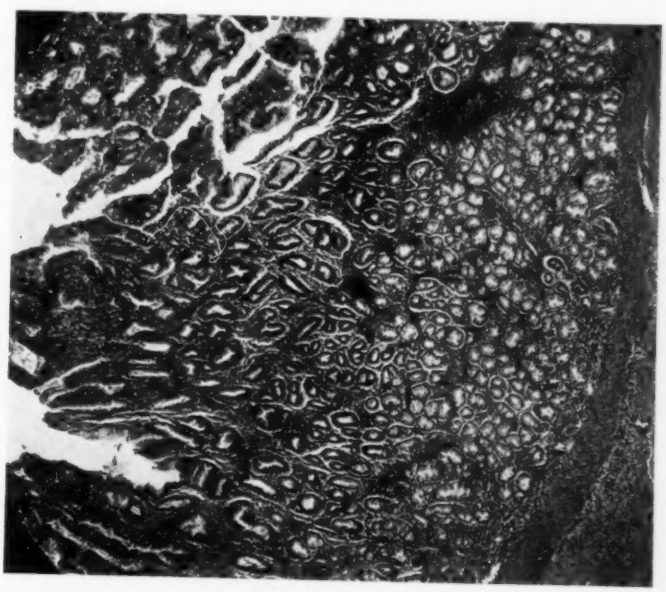

FIG. 2.—Atypical changes in glands in diffuse hypertrophic gastritis involving most of the mucous membrane in a case of peptic ulcer. The hypertrophy is not a result of the ulcer.

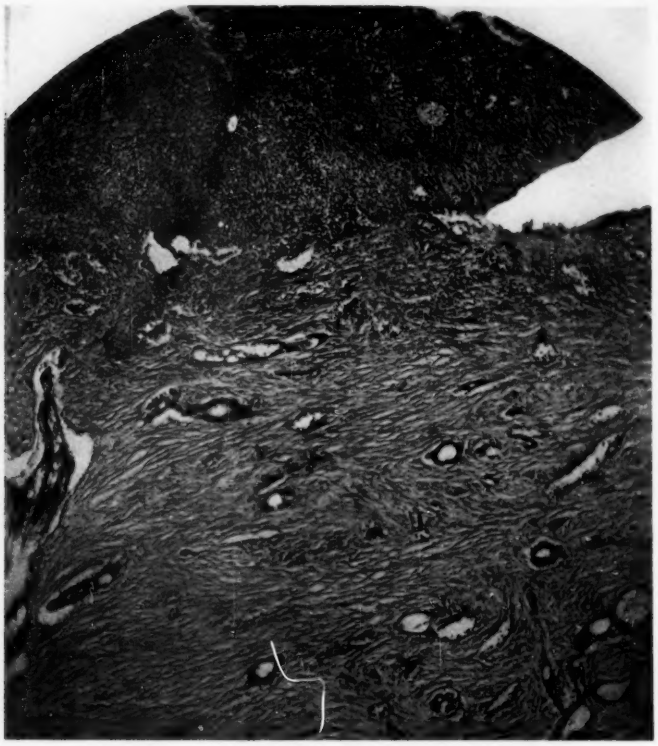

FIG. 3.—Case 5296. Fibrosing adenocarcinoma involving 6 cm. of the pyloric region. The section comes from the edge and base of a deep ulcer reaching almost to pancreas.

FIG. 4.—Case 5099. Inflammatory changes in the mucosa on the edge of a peptic ulcer grafted on diffuse round-cell carcinoma of pylorus. The carcinomatous process is invisible in this magnification.

FIG. 5.—Case 8253. Multiple peptic ulcers grafted upon diffuse carcinoma of pyloric region.

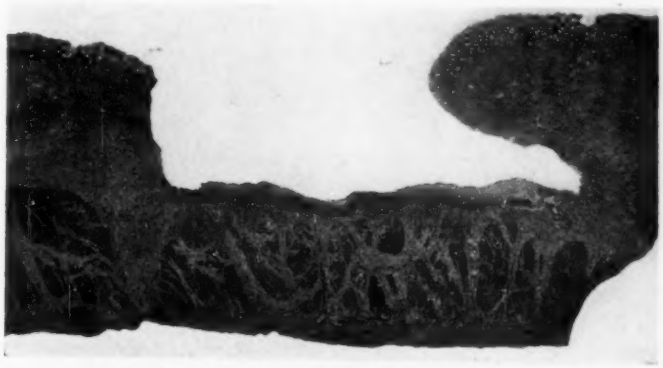

FIG. 6.—Cross-section of one of the ulcers in Case 8253. The muscularis is split up by diffuse carcinoma. The glands in the overhanging edges are unchanged.

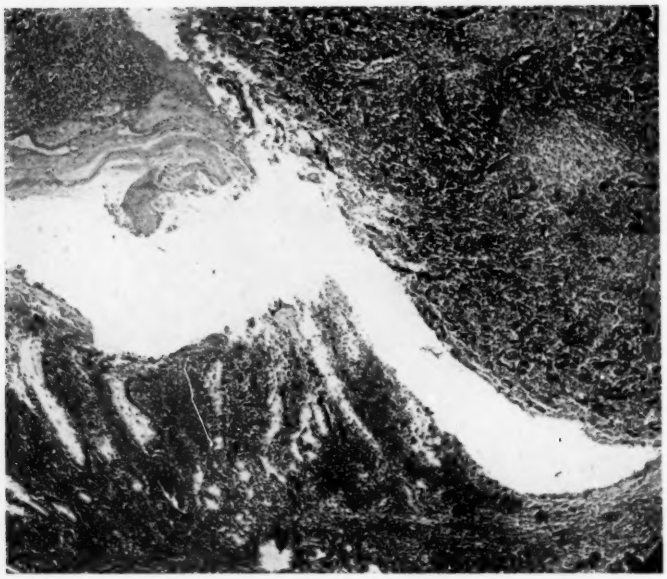

FIG. 7.—Edge of an ulcerating adenocarcinoma. The carcinoma (in upper right corner) is limited to a narrow peripheral ring protected by the overhanging edge of inflamed mucosa. The base of the ulcer is free from carcinoma. There are no atypical changes in the glands. The lesion is an early adenocarcinoma extensively excavated by the digestive action of the gastric juice.

FIG. 8.—Atypical proliferation and misplacement of glands on edge of an ulcer grafted upon diffuse carcinoma. The structure of the carcinoma is greatly altered by inflammation and cicatrization. The visible glands do not constitute the carcinoma.

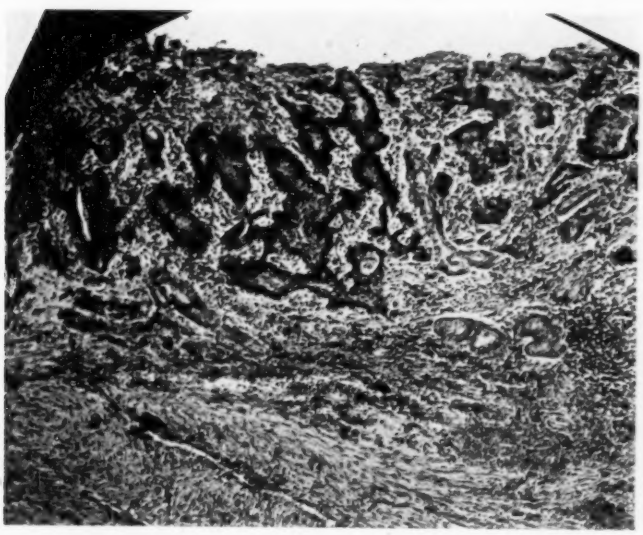

FIG. 9.—Atypical proliferation of glands on edge of a simple peptic ulcer. This lesion is not cancer.

one visualizes the conditions which must exist for the development of cancer by atypical proliferation on the edges of an ulcer, it is clear that the process must take considerable time, probably months, certainly in the best attested cases many years, and the base of the ulcer must become indurated, fibrosed and infiltrated by leucocytes which are antagonistic to tumor growth. Close to the surface of such a lesion it may safely be said to be impossible for cancer to advance. The natural paths of extension of such a secondary carcinoma will be those of least resistance which are outward, and such was evidently the course in Hauser's cases. Hence great importance would seem to attach to the condition of the base of the ulcer in the diagnosis between primary and secondary carcinoma.

(6) The occurrence of atypical epithelial proliferation in the glands on the edge of an ulcer is not sufficient evidence that the lesion is going on to cancer (Fig. 9). A safe application of the doctrine of precancerous lesions recognizes that the suspicious lesions may never pass beyond the stage observed. This rule is especially patent in the breast and prostate, where atypical changes are very frequently seen in chronic mastitis and prostatitis, but the disease terminates in cancer at most in only 15 to 25 per cent. of the cases. The same rule doubtless applies to the stomach, in which I find atypical proliferation on the edges of peptic ulcers is rather uncommon.

From the above considerations the writer is forced to conclude that the cancerous transformation of peptic ulcer is rather infrequent and probably does not exceed the incidence of 5 per cent. originally established. This proportion would be much smaller if only those cases were included in which the evidence is demonstrative, viz.: a long history of gastric ulcer, the limitation of the tumor to isolated foci or one portion only of the ulcer, and freedom of the base from infiltration.

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CAUTERY EXCISION OF GASTRIC ULCER

FURTHER OBSERVATIONS ON THE VALUE OF THE METHOD*

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of Rochester, Minnesota

In a previous communication [1] I described a method of using the actual cautery in the surgical treatment of gastric ulcer. At that time, the advantages of cautery excision appeared to be sufficient to commend it, and we believed that it would prove an important addition to the operations commonly employed in chronic gastric ulcer. Since that time, further experience has more than supported our early opinion of the method, its application has been greatly extended, and its value has been recognized by others, notably Scudder, Peck, and Coffey.

In the present communication I desire to make some observations based on 214 cases of gastric ulcer, in which the cautery has been employed in our clinic, to show the advantages of cautery excision and briefly to compare its results with those of other standard methods, particularly knife excision.

The first group of cases in which the cautery was applied comprised the lesser curvature ulcers in such high situations or so extensively indurated as to make knife excision an operation of difficult technic or poor surgical judgment (Fig. 1). Under the circumstances, although gastro-enterostomy alone could be counted on to relieve the symptoms in a certain percentage of persons with such ulcers, the advantage of being able, without additional risk, to destroy the crater of the ulcer, and to sterilize the infected area by means of the cautery, was perfectly obvious. The results in this group of cases were very satisfactory and the employment of the cautery was carefully extended so that at the present time in a large percentage of gastric ulcers the method appears to be the one of choice.

There are certain limitations in the method which should first be noted. Chiefly that it is not applicable to those ulcers which have definitely undergone malignant change unless the lesion is irremovable because of its size, situation or fixation, and that the procedure should be attempted only if the stomach can be sufficiently mobilized to enable safe exposure.

The value of the cautery in gastric ulcer seems to depend largely on two factors, namely, heat and perforation. The efficiency of heat as a sterilizing agent in infected fields is well known and widely employed. Heat has no superior in quickly and effectively destroying infectious foci, such as cervical, buccal or epithelial carcinomas, indolent ulcers, carbuncles, etc., and since Rosenow has demonstrated the elective localization of streptococci in gastric ulcer, the application of heat in such an infectious process is clearly indicated.

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* Presented before the American Surgical Association, June, 1918.

Complete perforation by the cautery point through the centre of the crater of the ulcer (Fig. 2) has been made an essential in the technic because of the clinical fact (drawn attention to early by Mayo, Clairmont and others and now generally recognized) that spontaneous and complete perforation of a gastric ulcer is, presupposing recovery from this accident, quite likely to be followed not only by the cure of the ulcer, but by the cure of the patient. The frequency with which nature attempts perforation is shown by the fact that in a very high percentage of ulcers a protected perforation has occurred by the time they come to operation (Figs. 3 and 7). The cautery technic will almost always (particularly if a thin shaving of the calloused peritoneal coat is made following the careful reflection of the

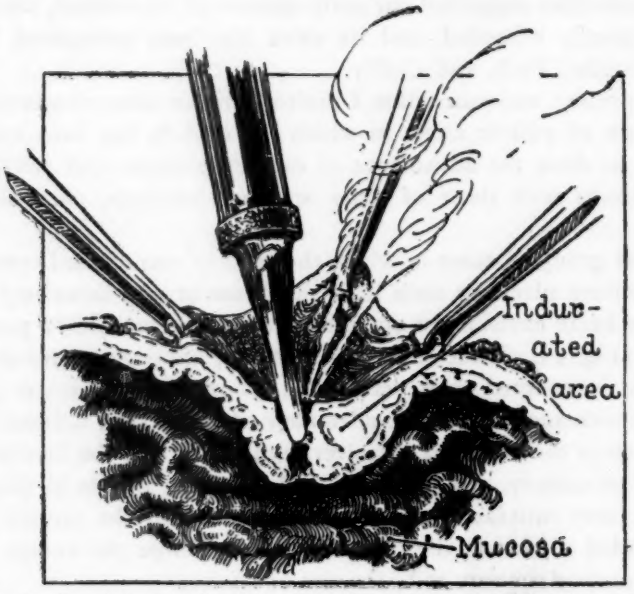

FIG. 2.—Complete perforation, by cautery, through the centre of the ulcer crater.

indurated gastrohepatic omentum from the wall of the stomach as shown in Fig. 4) reveal a minute but very definite point in the thickened gastric wall which marks the site from which the leakage has occurred, indicating the centre of the crater of the ulcer and serving as an excellent guide for the introduction of the cautery point (Fig. 5). Cautery puncture, combining as it does the beneficial action of heat with an artificial perforation, possesses a double efficiency and it is undoubtedly to these two factors that the success of the method is largely due.†

The most important advantage of cautery excision concerns its application in ulcers of the lesser curvature. In this situation the majority of gastric

† Since the original communication[1] Haines, of Cincinnati, has drawn my attention to the fact that perforation of a gastric ulcer by some blunt instrument had been proposed previous to that time.

FIG. 1.—Characteristic position of stomach with an ulcer of the lesser curvature. Moderately extensive induration and thickening of the gastrohepatic omentum.

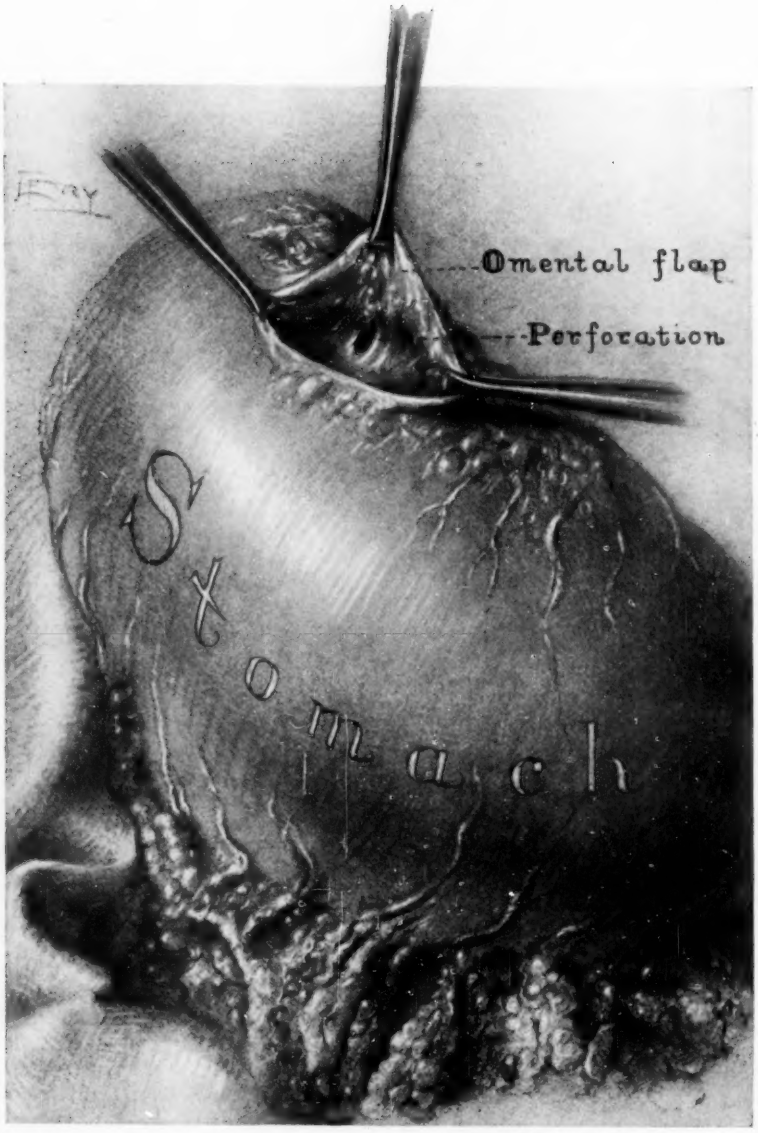

FIG. 3.—Gastrohepatic omentum dissected off ulcer area and peritoneal surface exposed.

ulcers occur, but the high incidence has never been satisfactorily explained although certain suggestive facts are in evidence. For example, the blood supply along the lesser curvature is much greater and of different arrangement than that on the greater curvature, a situation in which ulcer occurs with the greatest rarity; while the lesser curvature of the stomach, as Barber has recently shown, is extremely rich in vagi and sympathetic terminals, although the distribution of motor and sensory function in these terminals is not known. The significance of these anatomical characteristics is not understood, but enough evidence can be obtained by experimental methods alone to show that the lesser curvature of the stomach may well be given more regard by surgeons than has been afforded it in the past.

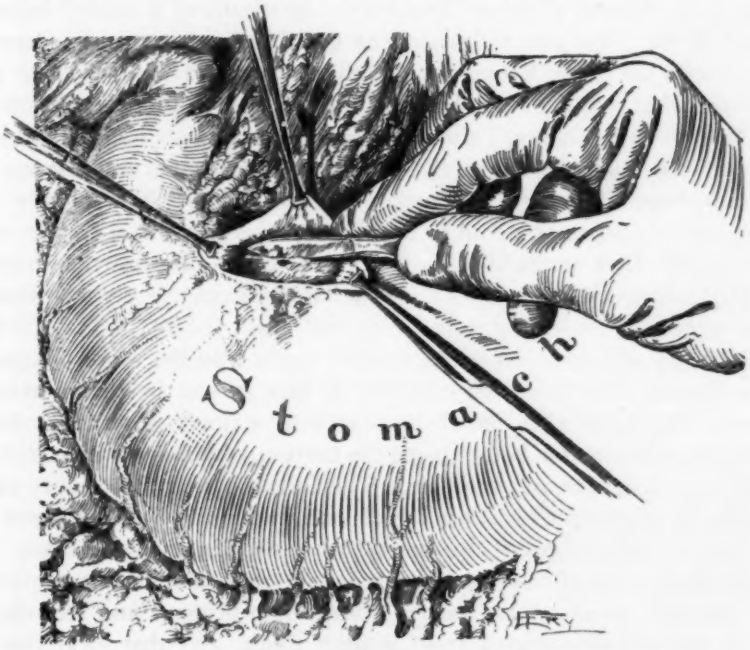

FIG. 4.—Shaving of thickened musculoperitoneal coats.

Clinical experience, too, bears out the observations of Barber and Stewart that excision of a segment of lesser curvature does definitely impair gastric motility, for it is now well known that excision alone of a lesser curvature gastric ulcer frequently fails to completely relieve symptoms, and in order to obtain the best possible results such an excision must always be combined with gastro-enterostomy. Cautery excision, on the other hand, reduces to a minimum interference with the future motility of the stomach. Carman, in röntgenologic studies of stomachs following different types of operation, has recently demonstrated that cautery excision and gastro-enterostomy gives much better motility and function and results in much less deformity than does knife excision and gastro-enterostomy. This fact can hardly be over-emphasized. Notwithstanding, therefore, the good results which follow

knife excision and gastro-enterostomy, if cautery puncture through the crater of the ulcer, with gastro-enterostomy, will give at least equal results, it is, quite aside from advantages which will be pointed out later, a preferable method on the score alone of being less mutilating in its accomplishment.

One objection which may be raised against cautery excision is in regard to its effectiveness in those cases of ulcer undergoing malignant change and which are otherwise excisable, but I believe it may be shown that not only is any deficiency in the cautery method more apparent than real but that it possesses certain advantages under such circumstances. Without going into a discussion as to the frequency with which gastric ulcer becomes gastric cancer, I may offer one fact which seems to be of considerable importance from a surgical point of view. In a review, by means of a careful follow-up system, of the 1,004 cases classified as gastric ulcer, in which operations were done in the clinic, I found that in those patients dying months or years later from what was known to be gastric cancer (or, as was more often true, thought to be gastric cancer) almost invariably malignancy had been strongly suspected, the lesion was not safely removable, and a gastro-enterostomy only had been done. Investigation further showed that death eventually from gastric cancer seldom occurred in those cases in which the operative report stated gastric ulcer unqualifiedly. In other words, although the surgically untreated gastric ulcer possesses a strong liability to cancer degeneration, the gastro-enterostomized ulcer shows very little such liability. This fact discounts largely any criticism of the cautery method on the score of ignoring the malignancy factor. Such criticism is further met by the practice we follow of shaving off a portion of the ulcer base or rimming out the crater for microscopic examination before using the cautery, with immediate resection if the ulcer is malignant and operable. The fact, too, that the cautery can be used in a large group of cases in which excision is impracticable more than offsets any disadvantages of the method when used in excisable cases. The investigations of Thalhimer and Wilensky are important in this connection. They were able to show that gastric cancer, both primary and secondary to ulcer, is sharply demarcated from healthy tissue, and that local resection 1 or 2 cm. from the edge of the macroscopic evidence of the tumor is sufficient in the majority of instances to remove all the disease. This being true means that heat used in an ulcer undergoing malignant change can, by careful application, be effectual in destroying early malignancy if no metastases are present. The destructive action of heat on the cancer cell is so positive it is not unreasonable to hope that in some of these large irremovable ulcers which have already taken on early malignant change in the ulcer base, the thorough cauterizing of the base may destroy these cancer cells and prevent an otherwise certain death from cancer later.

The actual effect of the cautery may be studied from four standpoints, (1) experimental evidence, (2) clinical experience, (3) operative mortality and (4) late results.

The original experiments conducted under the direction of Mann to

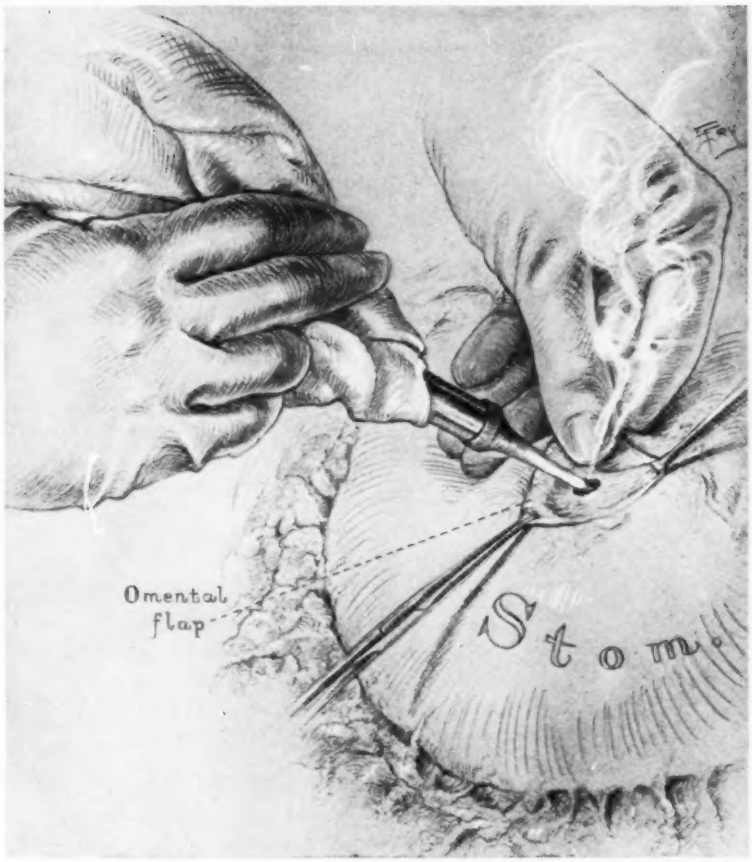

FIG. 5.—Peritoneal surface of ulcer prepared for application of cautery.

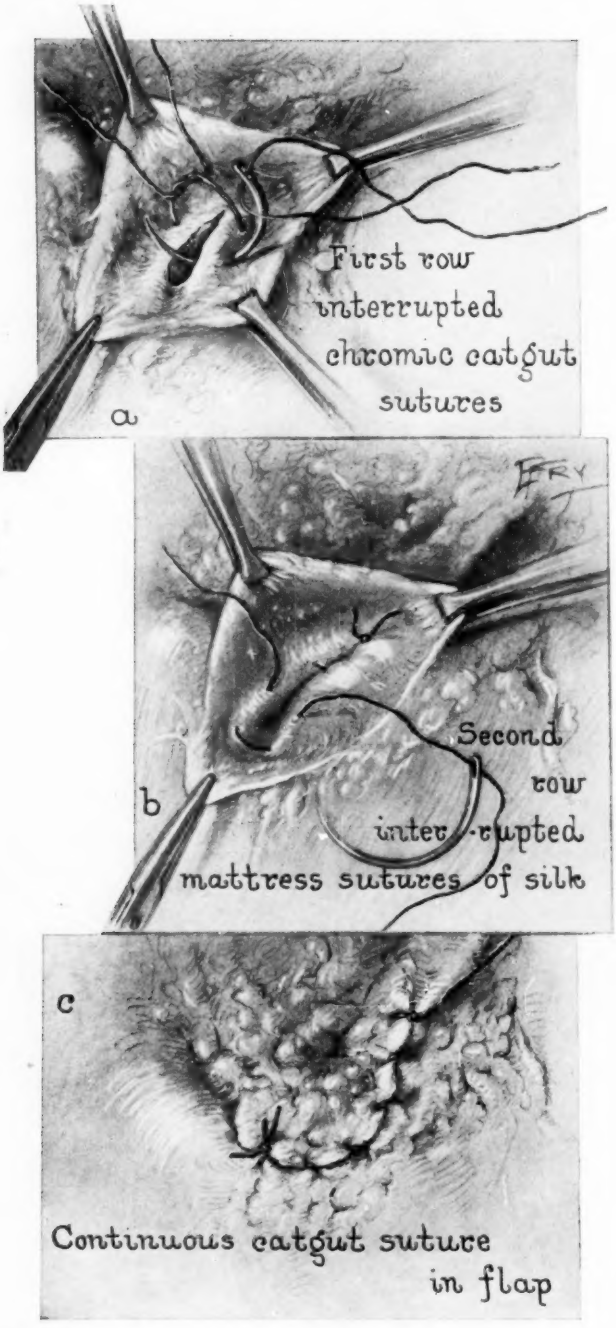

FIG. 6.—Method of closing cauterized opening. *a*, first row, chromic catgut sutures; *b*, second row, silk mattress sutures; *c*, third row, continuous catgut sutures.

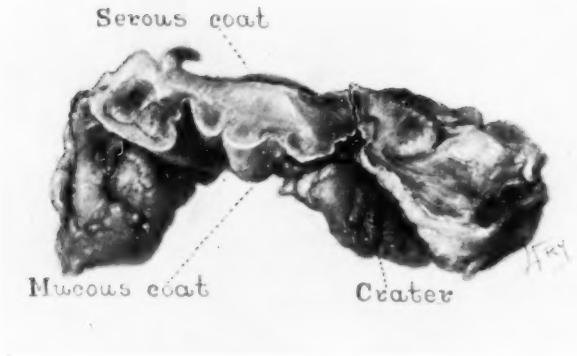

FIG. 7.—Cross-section of ulcer, showing tract of perforation.

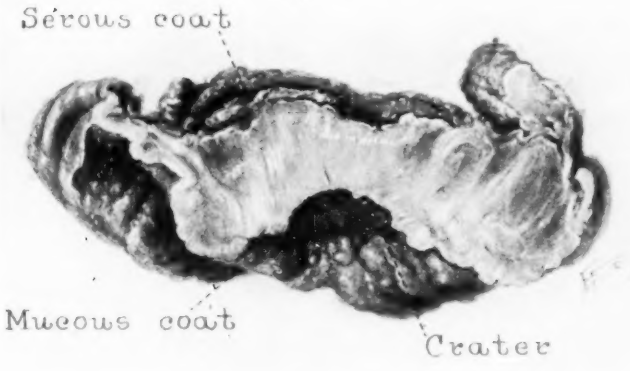

FIG. 8.—Half section of ulcer showing extensive induration.

determine the healing power of the stomach after an opening had been made by the cautery, and closed by suture, demonstrated conclusively that rapid and firm healing uniformly took place, even when the closure of the cauterized opening was more or less imperfect. The experiments carried out by Scudder and Harvey confirmed this and they showed further that in serial sections of the line of closure following cautery excision and of that following knife excision no marked difference in rapidity of repair was demonstrated. Experimental evidence, then, has demonstrated the readiness with which healing takes place in these cauterized areas.

We have had only one opportunity of observing in man the late condition of the stomach after the operation of cautery excision. In 1915 I operated on a patient (Case 120281) for a large gastric ulcer of the lesser curvature. The induration was so extensive and extended so high on the lesser curvature that not only was excision quite contraindicated but the possibility of a second ulcer was considered. Only one crater could, however, be determined. This, after its exact location on the peritoneal side, was exposed by mobilization, was punctured with the Paquelin and thoroughly cauterized, the opening closed, and a gastro-enterostomy done (Fig. 6). The patient made a good recovery and returned home. Later he contracted lobar pneumonia followed by empyema, and he returned to the clinic acutely ill, where, notwithstanding prompt and efficient drainage, he died. At necropsy the stomach was the organ of particular interest. In spite of the great induration along the lesser curvature at the time of the operation, there was no evidence that any pathologic condition had existed or that any operative work had been directed toward the lesser curvature. The gastro-enterostomy was normal. These findings were extremely gratifying inasmuch as the result was obtained in a case in which knife excision could not be done, and in which heretofore a gastro-enterostomy alone would have been made.

The low operative risk of cautery excision and gastro-enterostomy is shown by the fact that in the 186 cases in which this was the major operation there were two deaths, giving a mortality in the series of only 1 per cent. The necropsy findings in each of these two cases demonstrated that the field of operation was in perfect condition; the cause of death in one being pulmonary embolus on the eighth day and in the other pneumonia on the twentieth day. In comparing these statistics with those of knife excision and gastro-enterostomy we find that in the 89 cases in which operation was done by this method 3 deaths occurred, a mortality of 3.3 per cent.

The convalescence of the patients in whom cautery excision and gastro-enterostomy are done is uniformly smooth, and the clinical postoperative course bears out Carman's observation that better gastric motility is attained than in those operations (particularly excision of a V-shaped segment in the lesser curvature) which entail greater damage to the musculature of the stomach. The reports of the late results, as they come in, are most favorable. Of the 61 cases in which the cautery was used in 1914–1915 we

have positive information in 55. In this number there have been 4 deaths from all causes since operation, 2 already mentioned following operation, the other 2 of unknown causes at their homes in the three or four years after leaving the clinic. Of the remaining 51 cases operated on in the two years 80 per cent. of the patients report a satisfactory result (cured and greatly improved), 18 per cent. were improved in the sense of amelioration of symptoms present previous to operation, while in no instance did a patient report that he had not obtained relief from the operation.‡ The cases of knife excision and gastro-enterostomy in this period show corresponding figures of 70 per cent. and 15 per cent., while 15 per cent. of the patients state they are no better. These figures of mortality and late results have more force when it is remembered that the knife excision cases are essentially selected, inasmuch as this operation is done only when conditions are favorable, while the cautery is often employed in the very case in which excision is unwarranted because of the size, fixity and situation of the ulcer.

As to the relief of special symptoms, I would draw attention to the very important fact that in not a single instance has there been a recurrence of hemorrhage from the ulcer following operation by the cautery excision method. It is well known by surgeons of experience that operations for gastric or duodenal ulcers which have been associated with bleeding, do not always obviate later gastric hemorrhages. That bleeding has not recurred thus far in any of our cases following the use of the cautery has been a source of considerable satisfaction. One of the primary purposes also of the cautery was to lessen the likelihood of immediate postoperative hemorrhage and in this the method has fulfilled expectations.

From a technical standpoint, excision by cautery accomplishes much in a simple way which is not true of excision by knife. It is a common observation that the induration around an ulcer is out of all proportion to the size of the crater (Fig. 8), and that excision sacrifices, along with the actual infected area, the protective induration with which nature attempts to wall off the infectious foci which exist in the crater. Our experience with the cautery has shown that this wide excision is just as unnecessary as it is in the treatment of infectious foci elsewhere and that the indurated area can be restored to a healthy condition by destruction of the crater and thorough heat sterilization of the surrounding tissues as the cautery is held in the punctured crater. The heat is an important factor and would destroy adventitious cells for from 1 to 2 cm. in every direction. The utility of the cautery is particularly well demonstrated, therefore, in greatly indurated ulcers (the actual size of the crater is rarely greater than a twenty-five-cent piece) which can be safely mobilized. Knife excision under such circumstances, necessitating as it does complete removal of the indurated area, is an

‡ One patient (2 per cent.) after five months of relief developed similar symptoms and returned to the clinic. Re-examination disclosed indications of a gastrojejunal ulcer and operation confirmed such a diagnosis and corrected the difficulty.

unsatisfactory procedure if some substitute is available which will accomplish as much without unnecessary sacrifice of gastric wall.

The cautery, therefore, has been found of very great usefulness in gastric ulcer. Although I have considered in this paper only the 186 cases of gastric ulcer in which cautery excision was combined with gastro-enterostomy, we have also used it without any other operative procedure, as well as with various types of gastroplastics and pyloroplastics. In a few cases we have employed it to destroy small duodenal ulcers, particularly those associated with hemorrhage, and it would appear that in such cases the method has particular usefulness of application.

The apparent advantages of the method may be summarized as follows:

1. The cautery efficiently destroys the focus of infection in gastric ulcer without the sacrifice of nature's protective induration surrounding the ulcer crater.

2. It may be applied in a large percentage of gastric ulcers.

3. It entails a minimum of operative risk.

4. Clinical and röntgenologic evidence show better motility and function than follow knife excision and gastro-enterostomy.

5. It has a particular efficiency in obviating early and late postoperative hemorrhage.

6. The late results are better than those obtained with any other method.

7. It can be used in cases in which no other means of direct attack on the ulcer is justifiable.

8. It is probable that in gastric ulcer cautery, like knife excision, should always be combined with gastro-enterostomy.

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RELIEF OF UMBILICAL HERNIA BY THE CONDEMIN-RANSOHOFF TECHNIC *

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Acquired hernia at the umbilicus, as found in the adult, is a most difficult form of hernia to deal with, as it so frequently occurs in fleshy subjects who, before seeking operation, have allowed the hernia to grow to a large size and frequently to become strangulated. When strangulated, these cases early develop fecal vomiting, owing to the sac containing portions of the proximal small intestine. Patients with a fatty heart, fecal vomiting, a large mass of adherent omentum and possibly a portion of gangrenous intestine, present a condition which requires extensive operative measures and prolonged anæsthesia.

In the text-books and most of the articles treating with the radical cure of umbilical hernia, the entire detail is directed to the closure of the wound and not to the measures which may be taken to shorten the operation, and with it the period of anæsthesia. It is quite true when operating we should aim to obtain a radical cure, but it is equally true that a satisfactory and complete closure is of no avail if the patient is later to die as the result of the time taken to attain this.

In order that we may have the additional time necessary for the closure, our initial procedures should be so planned as to conserve as much time as necessary. The usual procedure has been to incise over the mass, open the sac, reduce the contents or deal with them as might otherwise be necessary, and then to excise the sac and close the wound.

In 1898 we began to operate by attacking the contents of the sac from within. The method of approach is as follows: An elliptical incision is carried about the tumor so as to remove as much skin as necessary, or to surround any ulcerated area. As soon as the sac is reached it is isolated down to the ring, completely exposing the fibrous structure, and extending a couple of inches above, below and laterally.

An incision is now made in the median line an inch below the ring, and the peritoneal cavity opened; the finger is introduced and with scissors the incision is carried completely about the ring, first on one side and then on the other, until the median line above is reached. The only point at which there is danger of dividing the intestine or omentum is in the upper segment. When this division is completed the entire hernial mass, including the sac, fibrous ring and contents, is lifted free from the abdominal cavity.

The next step is to remove the contents from the sac. To do this the fibrous ring is divided sufficiently to allow an inspection of the interior of the sac; the intestine and any free omentum is withdrawn and placed in the

* Read before the New York Surgical Society, April 10, 1918.

abdomen. The omentum is usually in large amount and adherent everywhere to the wall of the sac. It is not necessary to dissect this free, but, instead, it is to be ligated at the ring and the adherent portion removed with the sac.

Gangrenous intestine, if present, should not be removed from the sac, but excised, *in situ*, and anastomosis made. This saves much time and avoids handling the gangrenous intestine.

This technic we have used in a large number of cases, many of which have been strangulated. By this method the operative procedure has been simplified and much shortened and our mortality has been very materially reduced.

The procedure here outlined we presented before the Medical Society of the County of Kings [1] as an original procedure, but later found that it had been, with slight differences, previously described by both Condemin and Ransohoff.[2] To the latter is due the credit of first having given a complete description and drawn attention to its many advantages.

The only text-book which describes this operation in detail mentions it as a part of the Mayo operation for radical cure of umbilical hernia, although Mayo in his original paper [3] gives full credit to Ransohoff; Mayo's contribution dealing particularly with the method of closure.

The technic above described has the advantage of preparing the wound for closure by any of the recognized methods. If there has not been a wide separation of the recti, the edges of the sheaths are usually opened when dissecting out the fibrous ring, and we have the parts well exposed for immediate suture in layers.

For the Mayo method of closure it is equally well adapted, as the aponeurosis can easily be overlapped from above downward and the transverse suture introduced.

This technic is presented as it has the following advantages over any other method of approaching the sac in umbilical hernia:

First, it is the simplest method of dealing with the contents of the sac.

Second, if gangrenous bowel is present it may be removed without handling.

Third, large masses of adherent omentum can be removed with the sac and thus save the time necessary to free the many adhesions.

Fourth, if there are any ulcerated skin areas they are removed with the primary incision.

Fifth, it shortens the first stage of the operative procedure and greatly reduces the mortality.

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[2] Medical Record, vol. li, No. 5.

[3] Annals of Surgery, vol. xxxiv, p. 276.

CONGENITAL IDIOPATHIC DILATATION OF THE COLON OR HIRSCHSPRUNG'S DISEASE

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Hirschsprung's name [1] has become attached to this disease because his classical description of it at the meeting of the Berlin Congress for Children's Diseases in 1886 first brought its existence as a clinical entity to the general attention of the profession. In 1908 Finney,[2] collaborating with A. W. Fisher, presented a bibliography of 206 articles, complete to the time of his writing, and showed that more than twenty cases had been collected before Hirschsprung's. In his masterly contribution three additional cases were reported and the subject was exhaustively considered from every viewpoint. The first report on record seems to have come from the pen of Parry [3] in 1825. The first report in this country seems to have been made in 1867 by Lewitt,[4] of Chicago. In the nine years which have elapsed since Finney's monograph, about 175 articles on the subject have appeared, 147 references being appended to a case reported by Cadwallader [5] last year. Two of the most interesting and instructive of these contributions are those by Barrington-Ward [6] and by Porter and Weeks.[7] The disease is not so rare as most text-books would lead one to believe. All together more than 400 cases have been collected. Smith [8] states that he had seen 8 cases and had found 26 not included in previous collections in addition to 358 cases gathered by Schneiderhölm [9] in March, 1915, making a total of 392 reported to October 1, 1915.

The object of this paper is to add to the rapidly growing literature on the subject the report of one more case of true, congenital, idiopathic dilatation of the colon, to describe its pathology and to discuss it in the light of the etiological causes as listed by Finney. I am indebted for the opportunity to Dr. B. F. Zimmerman, who successfully operated and restored the patient to normal health and kindly presented the specimen to the museum of this department after exhibiting it before the Jefferson County Medical Society. The clinical data furnished by Doctor Zimmerman follow:

Clinical Data.—Miss O. R., aged twenty-one. Referred to me by Dr. C. L. Nichols, on January 17, 1915.

History.—Patient has suffered from habitual constipation since infancy. Large doses of strong purgatives have always been necessary. It has not been unusual for her to go from two to four weeks without an evacuation of the bowel. Enemata of little avail, the fluids usually being retained. She gives no history of any illness which could pos-

sibly be connected with her present trouble. Does not suffer from headache. Does not vomit. Appetite poor. Complains of a feeling of lassitude. Following an X-ray examination by Doctor Keith, a report of which is herewith included, Doctor Nichols, with the idea that the condition might be due to some obstruction by the valves, applied Pennington's rectal valve clips. These produced a destruction of a portion of the valves but afforded no relief.

Family History.—Had a baby sister who died in infancy from a congenital obstruction and has a sister four years old who has never been able to talk. Her mother has a large goitre, of the adenomatous type, in my opinion.

Report of Radiographic Examination (Doctor Keith).—Examination was made February 2, 1915. After cleansing the big bowel by enema, an enema of barium solution was given until the patient felt some discomfort. The amount of solution used was seven pints. A plate was made at this time which gave a shadow of a rather small rectum and a very large, dilated big gut from the junction of the sigmoid and descending colon to the cæcum. The transverse shadow of the descending colon is probably three inches in diameter, the cæcum being probably four inches in diameter. The splenic angle extends as high as the seventh rib, plates being made in the supine position. Diagnosis: Congenital megacolon or Hirschsprung's disease, probably due to congenital, anatomical narrowing of the rectum.

Operation and Subsequent History.—On May 12, 1916, a short circuiting of the bowel was done, the ileum being detached from the cæcum and by lateral anastomosis united with the sigmoid by means of a Murphy button. The colon was found greatly dilated from the cæcum to the lower part of the sigmoid, where it gradually reduced to normal diameter. Nowhere, however, even to the anal opening, was found any obstruction. The patient did well for eleven days, when she began to show symptoms of partial obstruction. These symptoms increasing, she was again operated May 24. The button had disappeared and the anastomosis was perfect. A kink in the ileum about two inches above the site of anastomosis, a result of adhesions, was producing the obstruction. A second anastomosis was done three inches above the first by the suture method. Recovery was uneventful. Following recovery from the second operation the patient did fairly well. She required much smaller amounts of purgative medicine. The colon, however, continued to fill up at times with gas and annoyed her greatly. So pronounced was this annoyance that she insisted upon the removal of the colon. April 23, 1917, colectomy was done. The ascending portion of the colon was apparently not much affected. The transverse and descending colon were enormously enlarged, the walls thick and leathery and the surface a grayish white. There was a long mesentery at the splenic flexure.

The patient made a complete recovery and since leaving the hospital, May 15, 1917, has taken but two doses of purgative. At the time of colectomy, the ileum was found to be considerably dilated. At present (May 1, 1918), the patient does not suffer from gas or consti-

pation. Her appetite is good. She has increased in weight, feels normal and is in a nurse's training course. She passed the Murphy button about May 5, 1917, nearly one year after its introduction.

Pathological Examination.—Gross: Specimen consists of large intestine to lower portion of descending colon (Fig. 1). Distal end is closed with a drawstring, which puckers it like a meal bag, to hold air with which specimen has been dilated. In this condition it has the following measurements: Length, 110 cm.; circumference about cæcum, 25 cm.; about ascending colon, 21 cm.; just proximal to hepatic flexure, 12.5 cm.; about middle of transverse colon, 20 cm.; about descending colon in largest part, 31 cm. Proximal end is formed by dilated cæcum from which, at site of ileocæcal valve, projects a puckered knob over which some fat has grown. On dissecting away latter, stump of cæcum is found about 20 mm. long. At meeting point of lineæ tineæ is a smaller knob which marks site of removed appendix. Both knobs are healed. In distal half of specimen wall is stiff, thick and leathery, pale grayish-brown with dilated vessels. Serosa is glistening, but through it circular muscle fibres appear distinctly, making line-like, annular ridges, while less distinctly the longitudinal fibres appear. There is little fat on this portion of specimen. Wall of proximal half is more normal, thinner and more flexible and yellower on account of more abundant fat. Mesocolon is absent from entire specimen. When opened, specimen is found practically empty. A small amount of fæces in a few places appears as thin flakes of pale brown plastered against mucosa. Mucous membrane is smooth, pale, grayish-brown, with a tinge of yellow and appears flattened and pressed out smooth. There are a few scattered, dark reddish-brown, oval or circular to irregular areas which look as if they might be pigmented with old blood. No ulcers found anywhere. When compared side by side a piece of hypertrophied distal portion appears three times as thick, macroscopically, as a piece from wall near the cæcum.

Microscopic: In two sections cut from thin wall of cæcum and from thickest portion of hypertrophied wall of descending colon the most striking difference is in muscularis which is from three to five times thicker in latter than in former. Mucosa in latter is also a little thicker, but no other lesion can be made out (see Figs. 2 and 3).

Discussion.—Hirschsprung's own division of dilated colons into those occurring in infancy (true megacolon) and those occurring in adult life (pseudomegacolon) is generally accepted. For the former German and Dutch authors use the term "Hirschsprung's disease," while French, English and American authors seem to favor the title "congenital idiopathic dilatation of the colon." The latter is preferred by Finney because it more nearly expresses our conception of the pathogenesis of the disease. There is abundant evidence that the disease has its origin in utero in a majority of cases. Its real cause is unknown. The acquired form results from some obstruction which develops after birth. For example, one [10] followed an operation for imperforate anus; another [11] followed fibrosis caused by earlier thrombophlebitis. The constrictions shown in Fig. 1 are like those mentioned by Leggett,[12] who found similar ones at the hepatic and splenic flexures and in the transverse colon. The congenital influence in this case is emphasized by the history of an infant sister who died without ever

FIG. 1.—Dilated colon showing splenic and hepatic flexures in natural positions. Puckered distal end marks site of section of descending colon above surgical anastomosis.

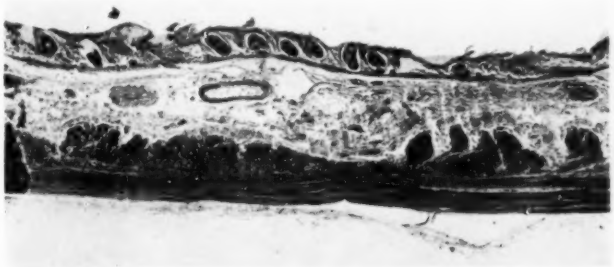

FIG. 2.—Photomicrograph of wall of cæcum (x 35).

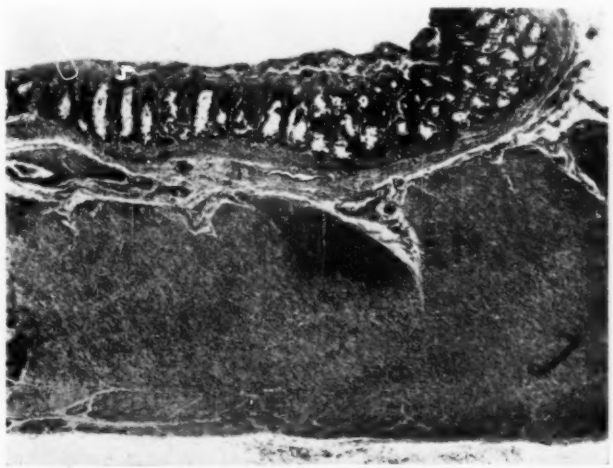

FIG. 3.—Photomicrograph of thickest portion of hypertrophied wall of descending colon (x 35).

having had a normal bowel movement. Welt-Kakels [13] reports a like feature in a case of an adolescent boy whose mother had borne another male baby who had died when eight years old. The latter never had a natural movement.

For a detailed discussion of the etiology of Hirschsprung's disease one should consult Finney's article. So far as the case herein reported is concerned it would seem to fit the view of Mya's modification of Hirschsprung's theory; namely, that the dilatation was a congenital anomaly and that the hypertrophy was a second process.

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MECHANICAL DERANGEMENT OF THE KNEE-JOINT*

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The knee-joint is the largest joint in the body, and, when considered from a purely mechanical point of view, would appear to be too weak and unstable to carry out its function. This apparent weakness is owing to the structure of the bony parts; the strength is furnished by the ingenious short, strong ligaments augmented to some extent by the insertion of the muscles into the ends of the bone comprising the joint. If the knee were called upon merely to support weight, the problem nature is confronted with would be simple, but in order that man may walk, motion must be permitted. This means that the various ligaments entering into the structure of the joint must be so arranged that when one is relaxed by a certain motion another will tighten to give the necessary stability.

The knee is a specialized hinge-joint and would have a mobility of 180 degrees if flexion were not stopped by the impingement of the calf on the thigh. Normally, with the knee extended, there is no lateral mobility or rotation permitted. Occasionally a person is seen who has some lateral motion with the knee fully extended. This stability lessens as the knee is flexed and lateral motion and rotation begin at a flexion of 150 degrees and increase as flexion increases. Morris states that a rotation of 36 degrees thus becomes possible, which is extremely important because damage to the semilunar cartilages occurs when this "arc of weakness" is entered.

The capsule surrounds the joint, and specialized parts of it are called ligaments. At the front is the patellar ligament arising from the tibial tubercle and the lower end of the patella, the latter merely a sesamoid bone in the tendon of the quadriceps. The capsule extends above the top of the patella for 2 inches or more, forming the suprapatellar pouch. On the inner side is placed the internal lateral ligament, a broad fan-shaped structure with the base upward, really a thickened portion of the capsule and not readily distinguishable from it. That the internal semilunar cartilage is very intimately associated with the ligament by the strong fibres of its deep layer is a fact of practical importance (Fig. 1). On the outer side is placed the external lateral ligament, a structure more deserving of the name of ligament, and it is oftentimes in two distinct parts. This ligament is separated from the true capsule by fatty tissue and the popliteus tendon lies between it and the bone. It arises from the external tuberosity of the femur, runs down and is inserted into the head of the fibula, piercing the tendon of the biceps. The external semilunar cartilage has not the same intimate connection with the ligament that its companion on the inner side has (Fig. 1). Posteriorly, the

* Presented before the South Dakota State Medical Association, Mitchell, May 21–23, 1918.

capsule is reinforced by a strong band of ligamentous tissue known as Winslow's ligament. It is of no special significance to the topic under discussion, except that it has to be divided when exploring the posterior compartment of the joint. The semilunar cartilages are crescent-shaped structures, fibrocartilaginous in consistency. They are wedge-shaped in cross-section, the thicker part being at the periphery of the joint and attached more or less firmly to the capsule. The thin portion points to the inner part of the joint, is free and can be lifted from the articular surface of the tibia. The external cartilage is almost circular, the narrow ends being attached in front of and behind the fibular facet of the tibial spine. The internal cartilage does not form such a complete circle. Furthermore, the anterior extremity is more or less loosely inserted into the rough surface near the anterior border, a matter of significance in considering the great frequency with which trauma is inflicted on the internal semilunar cartilage. Nature has attempted to remedy this somewhat weak insertion by providing a transverse ligament to join the two semilunar cartilages. The posterior end of the internal meniscus is attached to the back of the tibial facet of the spine and is firmly fixed. The firm attachment of the thickened convex border to the capsule and internal lateral ligament is of importance for the reason that any pull on the capsule tends to move the internal cartilage. Some fibres of the quadriceps are inserted rather low down on the inner side of the capsule and this prolongation might pull in such a manner as to disturb the normal contour of the fibrocartilage, thus causing the anterior extremity to be caught between the bone ends on attempted extension. The crucial ligaments are situated well inside the joint. The anterior or external arises from in front of the tibial spine and passes outward, upward and backward to be inserted into the internal posterior surface of the external condyle. The posterior or internal ligament arises from in back of the tibial spine and passes upward, forward and inward to be inserted into the anterior end of the external surface of the internal condyle. The anterior prevents the slipping forward of the tibia on the femur and the posterior prevents the backward slipping.

Below the patella is a fat pad extending under the upper portion of the ligamentum patellæ. Passing up from this pad to the intercondyloid notch is the ligamentum mucosum. Below, it is continuous with the synovial fringes at each side of the lower margin of the patella which forms the ligamentum alaria. Davis has suggested that these ligaments perform the function of "wipers" for the knee-joint, spreading the synovial fluid over the condyles as motion takes place.

Mechanical derangement of the knee-joint is a term generally used to designate a clinical entity produced by intrinsic causes. The condition is due to some disarrangement of the internal structures of the joint, caused by injury of the joint surfaces, the semilunar cartilages, the fat tags, or, if the term is broadly used, rupture of the crucial ligaments may be included. Occasionally in civil practice, the cause of the derangement may be found to be a body of extrinsic origin, such as a bullet. The great war has already

furnished numerous instances of bullets loose in the joint. As a definite group, the causes of the derangement, as seen in cases in the Mayo Clinic, have been due, respectively, to the internal semilunar cartilage, loose osteocartilaginous bodies, the external semilunar cartilage, and foreign bodies. From January, 1910, to March, 1918, we have operated on 162 patients for derangement of the knee. The internal semilunar cartilage was removed in 96 instances; loose bodies, osteocartilaginous in structure, in 57; the external semilunar cartilage in 5, and foreign bodies (extrinsic) in 4. In three instances the joint was opened and, no pathologic condition being found, it was closed. In two of these cases a search was made for loose bodies.

The symptoms produced by a damaged loose or fractured internal semilunar cartilage are usually quite definite and the diagnosis is correspondingly easy. The history as to the exact method of the production of the injury is important. The syndrome is typical, although the accident may be so sudden, the actual duration so short and the patient so confused, that it is occasionally impossible to obtain a clear history. It is generally conceded that injury to the semilunar cartilages very rarely, if ever, occurs with the knee in full extension. Derangement of the cartilage is quite common among the coal miners in England, caused, no doubt, by the position assumed by them in the low mining shaft, necessitating working with the knees partially flexed. In such a cramped position a man can usually better maintain his equilibrium by having the feet in moderate eversion. It is in just this position that the derangement is produced, namely, partial flexion of the knee with eversion of the foot causing some rotation outward of the head of the tibia on the femur. As I have stated, there is, when the knee is slightly flexed, a certain laxity of the joint permitting some lateral mobility and rotation. With the knee flexed to about 150 degrees and the foot everted and rotated outward, the relaxed internal lateral ligament allows of some separation of the internal condyle from the internal tuberosity of the tibia. When the accident occurs and the force continues, with the foot in eversion, there is a tendency for the tibia to rotate outward on the femur, carrying with it the internal semilunar cartilage, and as attempt is made to extend the knee, the internal condyle of the femur rolls down on the anterior extremity of the cartilage, catches and holds it. Something must give way. The semilunar cartilage must slip from between the bones (the most fortunate thing that can happen), the applied force must stop in time (almost an impossibility) or the cartilage will be torn from its anterior attachment or fractured. The meniscus is fibrocartilaginous in structure, and very seldom tears completely in two. It may rip in a multitude of ways, perhaps the most common being a tearing free of the anterior third or fourth so that it lies loose, attached by a pedicle in the joint. Such an injury is followed by locking of the joint at intervals, causing various degrees of disability. If the rotation of the tibia on the femur is considerable at the time of the accident, the condyle of the femur may catch the cartilage farther back and rip it longitudinally through the middle three-fifths. The outer piece of the cartilage will then be forced outward and will lie to

the outer side of the inner condyle near the crucial ligaments, being still intact at the anterior and posterior fifths (Fig. 2). The clinical history in such a case is usually that the disability following the accident is marked, the swelling and effusion persist for some time, but the dominant residual sign is lack of full extension. Flexion in such a case is usually normal and there is seldom the recurring of the locking that is present in the case in which there is a loose anterior extremity or a loose body. The patient presents himself with some effusion in the knee-joint and lack of extension and gives a history of a feeling of insecurity on walking that may necessitate crutches. The symptoms depend largely on the type of injury inflicted on the cartilage. If the history of locking is not definite or the physical signs, for example, lack of extension, are not definite, the surgeon should beware. Often the patient does not tell his story well and it is only by carefully going over and weighing the details that a conclusion can be reached. It is interesting to note that in the armies at war, this train of symptoms is seized on by the slacker as a means of being invalided out of service and only by the most careful investigation of the symptoms can it be ruled out. There may be such a laxity to the capsule in certain cases, in which the knee is partially flexed and the foot rotated outward, that the anterior portion of the internal meniscus will be caught on extension, and will slip out before serious damage is done. Pain, effusion, and disability will ensue. At operation, an almost normal looking cartilage may be shown with but a trifle too much mobility, such motion being participated in by the capsule in this area. In such a case, removal of the anterior three-fifths of the meniscus affords relief.

It is generally conceded that the patient should not be operated on if there has been only one locking or derangement. This is particularly true if the semilunar cartilages are involved. It is probable that if all derangements of the knee, accompanied by locking, were treated by reduction at the time of the accident, and followed by a plaster-of-Paris cast for from four to six weeks, there would be comparatively few recurrences. Unfortunately, this is not done, and the usual story is that there are repeated lockings following the accident, making surgical intervention necessary.

In cases in which there has been locking for years, the loose end of the cartilage may be palpable, and occasionally it has deposits of calcium in it sufficient to cast a shadow in the röntgenogram. As an aid to diagnosis of semilunar cartilage derangement, the röntgenogram is useful only in excluding loose osteocartilaginous bodies, but it should be employed in every case of knee-joint derangement. The semilunar cartilages are most frequently the cause of the disability in early adult life, although they are by no means limited to this period.

The external semilunar cartilage is much less frequently involved than the internal and there are very good reasons for this. The rotation and lateral mobility are less on the outer side and the external meniscus is quite loosely attached to the capsule; thus it is permitted more motion and is able to glide out of harm's way. The shape, as has been mentioned, is different,

as the anterior and posterior extremities nearly meet at the tibial spine, and the circle is practically complete. The internal meniscus is more C-shaped, the anterior extremity being loosely attached. In this series of 101 operations on the semilunar cartilage, the external was removed five times. In two of these, the results have been unsatisfactory; it is probable that that cartilage was not at fault and we must acknowledge an error in diagnosis. Jones states that to eight internal semilunar cartilages at fault the external cartilage is at fault but once. Other authorities place the proportion anywhere from 10 to 1 or from 50 to 1. In this series, it is certainly no lower than 20 to 1. It, therefore, is clearly evident that an external semilunar should be removed only on a definite history of pain on the outer side of the joint, in conjunction with distinct locking. Jones has seen cases with derangement of the external semilunar cartilage in which the pain was all referred to the inner side. The removal of a damaged semilunar cartilage gives most excellent results. The technic employed must be rigidly aseptic; the operation is simplified by the use of the tourniquet. The type of incision used is the lateral, or so-called condylar, care being taken that the internal lateral ligament is not needlessly sacrificed. On the outer side, the external lateral ligament is placed more posteriorly and is readily avoided. While splitting the patella longitudinally gives better general inspection of the joint, it is not well adapted to the removal of the semilunar cartilages. The knee should be kept at absolute rest for one week after the operation, and this is best accomplished by a plaster-of-Paris case. Some surgeons advise putting the patient in bed with merely a bandage about the knee, and encourage motion immediately. There are two objections to this. First, the patient on awakening from the anæsthetic may move the leg too freely and cause hemorrhage. Second, it is much better to keep any wound at rest until the blood-clot has had time to partially organize. The superficial stitches may be removed at the expiration of a week, the deep sutures three days later, and the patient encouraged to get about on crutches, putting a little weight on the leg. Two weeks after operation he should be without support of any kind. A little effusion may follow, but if the knee is bandaged this will gradually subside. In three weeks the patient is usually fit for his work.

Loose bodies next to the internal semilunar cartilage in this group have been the most frequent cause of derangement. In a general classification of loose bodies, would be included the loose bodies of unorganized tissue, such as the corpora oryzoidea (rice bodies), found in tuberculosis, but which never cause mechanical derangement. Occasionally a mechanical derangement may be due to a fibrous, pedunculated loose fat tag. In no case in this series could this be definitely decided on as the sole cause. Fat tags were removed in three cases in conjunction with the internal meniscus. Therefore, I shall discuss only loose bodies of definite structure, osteocartilaginous bodies, or those of foreign substance, such as a bullet or a needle, although the latter may be almost disregarded in this series, since there were but four, one bullet, and three needles. The needles were not, strictly speaking, loose,

one being in the soft tissues and the others in the cartilage of the internal condyle.

The osteocartilaginous bodies may be said to be produced in three ways, although trauma enters into the etiology in all. A loose body may be produced by direct trauma in a normal, healthy knee. A fall on the flexed knee against a hard object, such as a stone, may inflict such severe trauma to the internal condyle of the femur, the external condyle, or the patella, that a piece of the articular surface may be knocked off. In our experience, the internal condyle has been the most frequently involved in this manner. In one case suspicion seemed to point to the external condylar surface as the point of origin. In no case has the patella been the demonstrable origin. In our cases, syphilis *per se* has not been an etiologic factor. We have noted the presence of loose bodies in certain Charcot knee-joints, but have not considered that they should be classified under mechanical derangements, and in this paper they are not taken into consideration.

There has been definitely established as a clinical entity a group of persons who are prone to produce loose bodies, in every instance in this series the internal condyle of the femur being the area responsible. Koenig first described this condition, giving it the name of osteochondritis dissecans, and in this country Freiburg and Wooley and Ridlon first drew our attention to it. In a few instances, we have encountered it in both knees. The trauma or motion producing the body, or at least producing the first symptoms, is usually trivial and nothing particularly unusual, such as when the person turns sharply or arises from a sitting position on the ground. It is quite evident that the joint surfaces are not healthy in such cases. For some reason, desiccation of an area takes place, generally on the internal condyle a little to the inner side and just adjacent to the point at which the posterior crucial ligament is inserted (Fig. 3). Koenig's theory was that the end artery supplying this area became plugged and the part became under-nourished and sloughed off. In one instance a young man had recurrent locking. The röntgenogram showed the typical picture of osteochondritis dissecans, the body evidently resting in the depression where it originated (Fig. 3). On opening the joint, the area was readily distinguished, a line of demarcation could be traced surrounding the body, the latter being about three-fourths inch in circumference. It was necessary to cut the body loose in order to remove it. Whether or not the body had ever been free was not definitely clear. It may have been previously hanging on a pedicle, have become lodged in the depression and fibres had formed about it to hold it there. My impression was that these thin adhesions were not strong enough to have held the body there indefinitely and that it would later, on the infliction of some slight trauma, have become a loose body. The number of loose bodies produced in this way rarely exceeds two or three and careful inspection of the röntgenograms will disclose the source as a flattened area in the internal condyle.

The patient may present a knee actually distended with loose, movable

osteocartilaginous bodies which feel like a sack of marbles. The röntgenogram may show a synovial cavity greatly distended with a varying number of these bodies (Fig. 4). Bland Sutton reported one case in a young woman who had 1047 bodies removed without a recurrence of symptoms. In one of our cases more than 200 were removed. Such a condition had best be described as osteochondromatosis. The röntgenograms show the joint lines to be clear, thus forcing us to look further for the cause. On opening the joint, the picture is unusual. There is an associated synovitis; the lining is inflamed, somewhat thickened, and pedunculated into teats. These pedunculated masses vary in size, some are fibrous on the tip while others, still more advanced, are cartilaginous, becoming bulbous. As these bulbous portions become gradually larger and heavier, they drop off, wander about the joint and, nourished by the joint fluid, increase in size. What the etiologic factor back of this is, it is impossible definitely to determine. That it is of infectious origin does not seem plausible. There are factors which suggest it to be of the order of new growth. The synovial membrane is developed from the same layer of mesial blastema as is the cartilage of the joint surfaces, and it has been suggested by Whitelocke that the synovia tends to take on cartilaginous structure. In one of our cases, this condition developed coincidentally with a chondromatous formation in the lower end of the femur and later became malignant, the patient becoming cachectic, and dying with metastases in the lungs (Fig. 5). Such an association of growth on the synovia and in the cartilage is evidently rare, but very suggestive that the condition is a benign neoplastic one. Our patients with only the synovia involved have remained well, and in all the reported cases the patients have apparently had no recurrences. Just why the process should be brought to a standstill by the removal of the large formed bodies is difficult to understand; however, it is a clinical observation substantiated by but comparatively few cases.

The symptoms produced by the loose body or bodies are catching or locking, at irregular intervals associated with pain and perhaps effusion, followed by a period of relief depending on whether or not the body finds a resting place that does not permit of its being caught between the articular surfaces. If it lies above the patella in the suprapatellar pouch, in the posterior compartment, or even in the intercondylar space, locking will be absent. The irregularity and uncertainty of the locking, producing pain and sudden disability sometimes so extreme that the patient may fall to the ground, causes him to seek relief. Effusion may be present, and hypertrophic arthritis, although whether the latter produces or is produced by the loose bodies is not always definite. There is very little question, however, that some loose bodies are produced, particularly in elderly persons, by the marginal osteophytic growths in marked cases of hypertrophic arthritis breaking off and wandering about the joint and increasing in size (Fig. 6). Most probably the slight degree of hypertrophic arthritis seen in younger persons with loose bodies is secondary to the latter. It may be almost arbitrarily stated

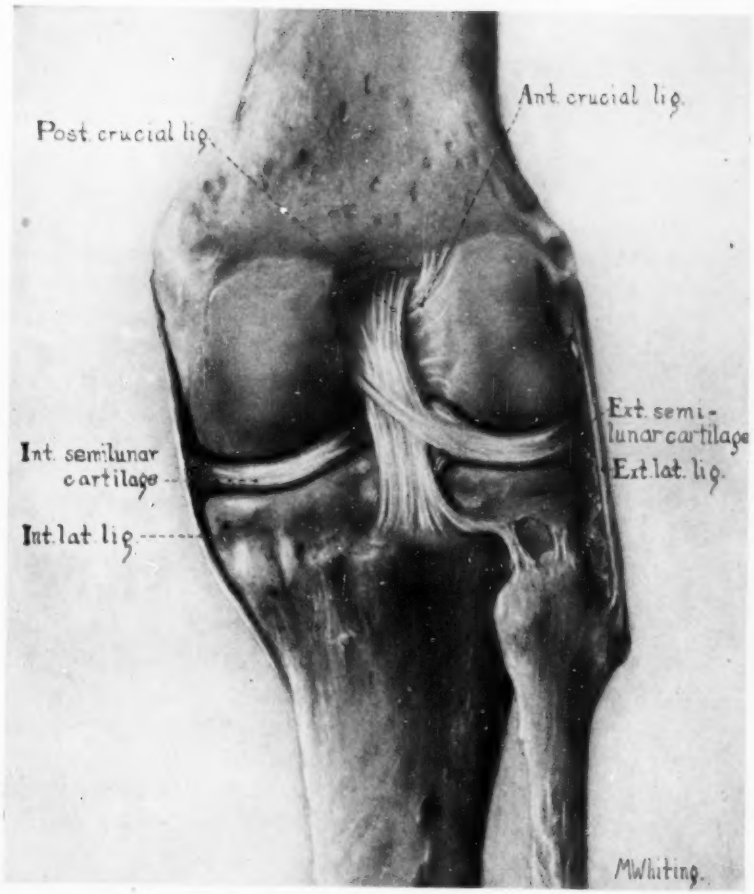

FIG. 1.—Showing intimate relation of internal semilunar cartilage to internal lateral ligament and the lack of this relation of the external semilunar cartilage to the external lateral ligament.

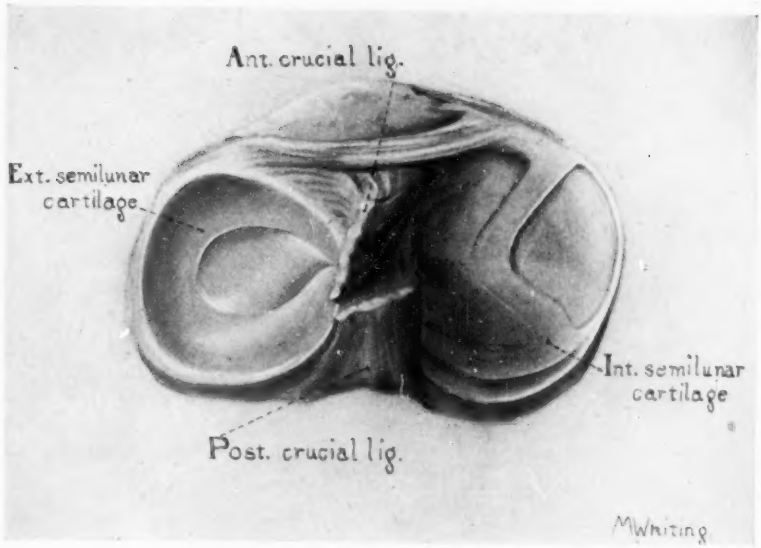

FIG. 2.—Showing internal semilunar cartilage displaced outwardly; anterior portion blocking extension.

FIG. 3.—Osteochondritis dissecans. Loose bodies arising from the internal condyle resting in the spot of its origin.

FIG. 4.—Osteochondromatosis of the knee-joint in which the loose bodies originate from the synovial membrane.

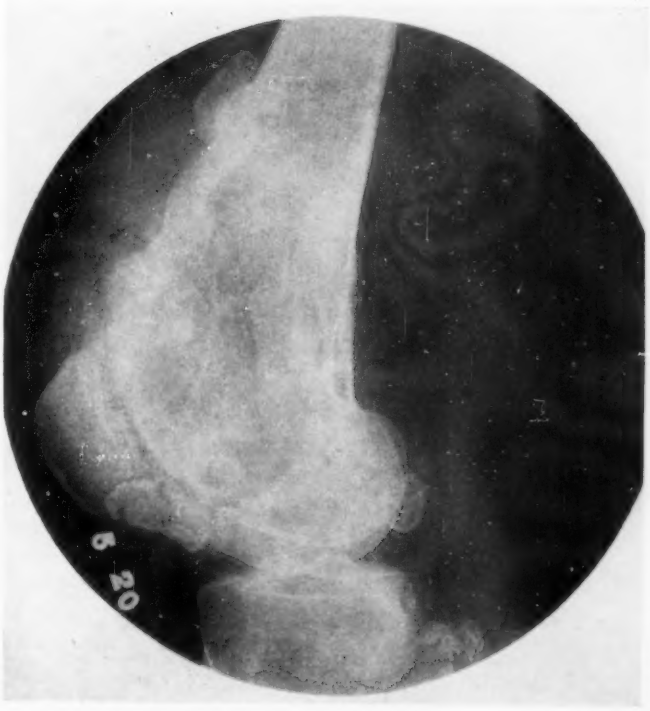

FIG. 5.—Osteochondromatosis associated with a malignant tumor of the lower end of the femur (sarcoma), later causing death.

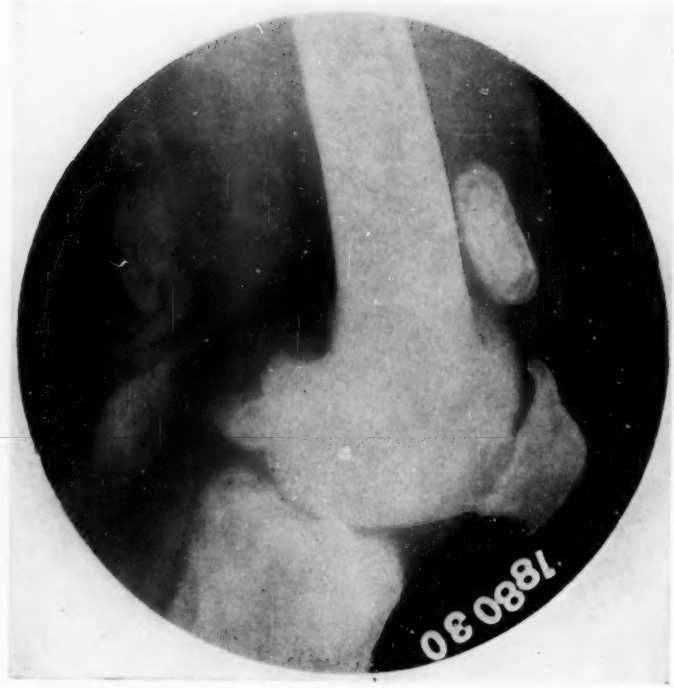

FIG. 6.—Loose bodies due to osteophytic growths of hypertrophic arthritis.

that the presence of loose bodies demands their removal, the general condition of the patient being taken into consideration.

If the loose bodies are single or only a few, and are in the suprapatellar pouch, they may ordinarily be removed under local anæsthesia. The knee is carefully prepared, the skin and subcutaneous structures are anæsthetized, and the loose body carefully palpated and held firmly between the fingers. A sharp cutting needle is thrust through the skin directly into the body, thus fixing it securely. With a sharp knife, the dissection is carefully carried down to the body and it is removed. After this simple procedure, the patient may be permitted to walk the same day. When the body is situated in the middle of the joint, as definitely ascertained by the röntgenogram, usually in a notch or a depression in the internal condyle, the inner condylar incision, as used in the removal of the internal semilunar cartilage, may be employed. If, however, exploration of the entire anterior compartment is necessary, the patella should be split longitudinally, the fibres of the patellar ligament divided, and the fibres of the quadriceps split a short distance above the patella. If there are loose bodies in the posterior compartment some may be successfully forced through into the anterior section. This is not always possible, and it may be necessary later to enter the posterior compartment by a posterior incision. It has been our custom not to do this at the primary operation, but preferably about two or three weeks later, in the meanwhile not allowing any motion of the knee. The posterior approach is not easy, particularly if the patient is fat or very muscular. The incision is six inches in length, running down the middle of the popliteal space. The centre of the incision is located over the joint line. It is preferable to dissect down between the heads of the gastrocnemii so as to keep the nerves and vessels to the outer side. The popliteal muscle is dissected through, the ligament of Winslow is divided, and the joint entered. By slightly flexing the knee, the capsule is a little relaxed and curved forceps may be introduced. If the bodies cannot be removed in this way, it may be necessary to force them out by palpation both within and without the wound. It is not always easy to remove all of them.

Following operations on the front of the joint when the capsule is opened on the inner side or the patella split, a plaster-of-Paris case should be applied and worn, in the latter case for three weeks. When the posterior incision is used a case is necessary for a week only. Rupture of the crucial ligaments does not produce typical mechanical derangement of the knee. The disability, however, is extreme. If the anterior crucial ligament is torn, the slipping forward of the tibia on the femur will be permitted, whereas rupture of the posterior crucial ligament will permit a slipping backward of the tibia on the femur. Open operation for suture is not necessary. If the knee is placed in the normal or a very slightly flexed position in a case well padded to take care of the swelling, an excellently functionating joint will result.

CONCLUSIONS

1. Mechanical derangements of the knee are usually produced in the order named, by a damaged internal semilunar cartilage, by loose osteocartilaginous bodies, and by the external semilunar cartilage.

2. Loose bodies of extrinsic origin produce derangements but are not frequent in civil practice.

3. Loose bodies *per se* demand removal.

4. A patient giving a history of mechanical derangement owing to a damaged semilunar cartilage should not be operated, unless the locking is repeated or reduction cannot be accomplished in any other way.

5. In properly selected cases the operative results are excellent.

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TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting, held February 27, 1918

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

REPEATED PERFORATION OF GASTRIC ULCER

DR. J. P. HOGUET presented a man fifty-two years of age, who came into the Hudson Street Hospital on March 20, 1917, with all the clinical symptoms and physical signs of a perforated gastric ulcer. He was operated by Doctor Turnure on the same day. The history of the operation states that the perforated ulcer was ¼ inch in diameter, situated on the anterior surface of the stomach one and a half inches from the pylorus, with an indurated area of ½ inch surrounding it. The perforation was sutured with several layer-sutures of chromic gut. He made a perfectly good recovery and left the hospital on April 8th. He remained well until December 22, 1917, when he came into the hospital with the history that for a week he had been constipated, and at times dizzy; during these dizzy attacks he vomited, usually about two hours after eating. Also during these attacks, he complained of pain in the epigastric region referred to the angle of the right scapula. On the day before admission he had a severe attack. He was operated on the day of admission, as he had all the clinical symptoms and physical signs of an acute perforation of the stomach. A perforated gastric ulcer was found at exactly the same place as at the first operation. There was visible rather a wide area of cicatricial tissue and in the middle of this area was the perforation about ¼ inch in diameter. There was a considerable amount of free fluid in the abdominal cavity and the perforation was closed and a gastro-enterostomy done in the hope that by this means another perforation might be prevented. His recovery was uneventful and he has remained well up to the present.

CARCINOMA OF THE UNDESCENDED TESTIS

DR. J. P. HOGUET presented a man, aged thirty years, who was born with an undescended testicle. One year ago last April, he noticed a swelling in his groin; this swelling became painful after a few months and later there was no pain at all, but the size of the growth increased greatly. He was first seen in April, 1917, when he had a large tumor in the groin with an empty scrotum on that side. The tumor was freely movable and was not tender—the typical picture of a large tumor of an undescended testicle. Operated upon on April 20th, at the French Hospital. Tumor removed by

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a high ligature of the cord. The pathological report was that the tumor was an embryonal carcinoma.

DR. WILLIAM A. DOWNES referred to a case in a man of forty-five years, with an undescended testis, who gave the history that he was able to push the mass into the abdomen easily. For twenty years he had been conscious of this condition and then the testicle gradually began to enlarge, forming a tumor the size of an orange which proved to be carcinoma at operation. Considering the case reported by Doctor Hoguet, it raises the question whether a man entering the Army with an undescended testis might not later, from the various exercises, drills, etc., so traumatize the mass as to cause malignant change to take place.

RETROSTERNAL GOITRE

DR. J. P. HOGUET presented a woman who came into the French Hospital last April, with a tumor in the midline of the neck about an inch to an inch and a half above the sternum; he operated her at that time, thinking she had a simple adenoma of the thyroid that could be easily enucleated. A simple adenoma was found, but there still seemed to be something behind it, and, going further, there was found another tumor which was larger than the first, seated directly behind the sternum. Dr. James Ewing reported two separate tumor masses completely circumscribed: the smaller a simple adenoma; the larger entirely composed of colloid material.

CONGENITAL HERNIA OF THE DIAPHRAGM

DR. WILLIAM A. DOWNES presented a boy, seven years of age, who was admitted December 28, 1917, with the history that about five and one-half years ago he began to vomit almost immediately following meals. The vomiting was in periodic attacks lasting from two to three months with an interval of the same length free from any attacks; this continued until three and one-half years ago when he ceased vomiting for eight or nine months. During the nine months interval free from vomiting he gained rapidly in weight. Twenty months ago the vomiting began again with no free intervals except for a day or two, occasionally there was discomfort after eating and if vomiting did not occur he would bring it on by " putting his finger in his throat "; the vomitus was of food freshly masticated and in amount from about one-half to the entire meal.

When he was two years of age he fell down a flight of stairs. When admitted he was poorly nourished and undersized.

His chest was very long and narrow with very prominent ribs, poor expansion. Liver dulness to the fourth rib anterior right side; and the cardiohepatic angle obliterated, the posterior dulness of the liver reached the fourth intercostal space; otherwise lung signs clear. Heart—the apex in the fourth space just inside the nipple line; on percussion the cardiohepatic angle obliterated; tympanitic note at the third and fourth interspaces just to the left of the sternum; the heart dulness appears extending well beyond

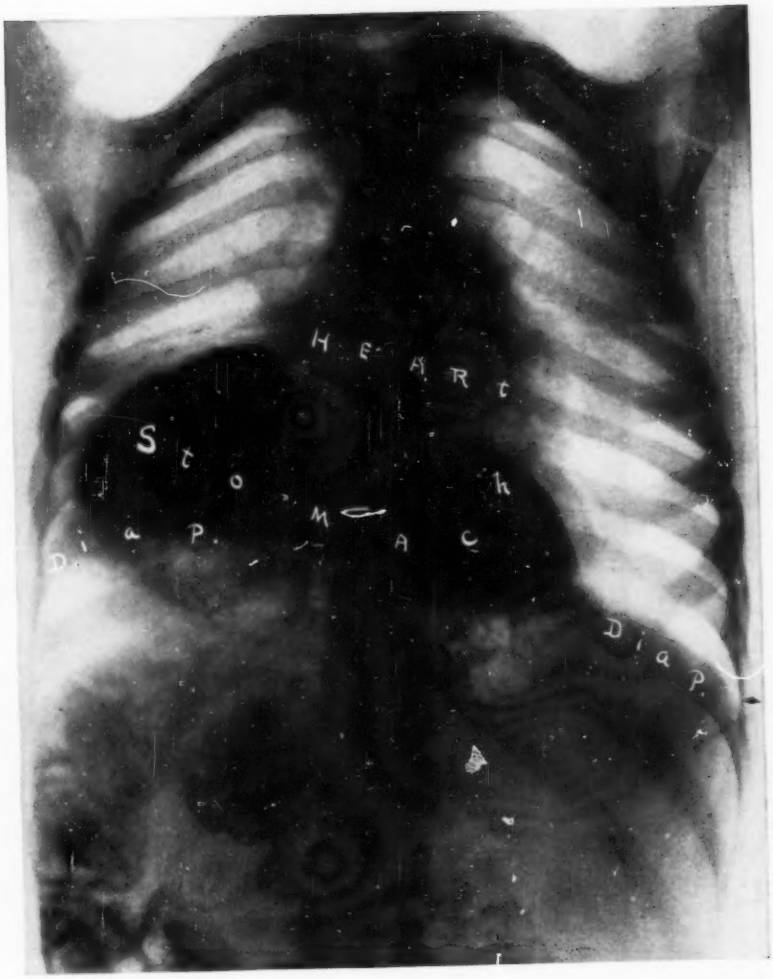

FIG. 1.—Case of congenital diaphragmatic hernia. Male aged seven years. (Radiographed by Dr. L T. Le Wald.)

the nipple line, suggesting displacement of the heart to the right. Succussion sounds heard in the right lower chest on shaking. Abdomen scaphoid; walls soft; no masses felt. Skiagraph shown in Fig. 1.

On admission, blood count: Red blood-cells, 3,400,000; hæmoglobin, 65; white blood-cells, 6500; polymorphonuclears, 64; leucocytes, 36. Wassermann negative. Urine negative. Weight, twenty-four pounds.

During the first day postoperative the patient was in good condition, without distention, nausea or vomiting. On the second day a stomach lavage was given, with dark brown fluid return, and patient complained of some pain in the region of the wound.

Third day postoperative the stomach was again washed out, with greenish fluid return; relief of pain. Fourth day showed some distention of abdomen and patient still complained of pain in abdomen. Fifth day there were no complaints. Sixth day he complained of pain in abdomen and there was some subcutaneous emphysema noted along the right margin of the sternum; disappeared in about three days. Eighth day he was very comfortable and from then on complained of very little pain except some around the wound.

Weight on admission twenty-four pounds. By the fortieth day it had increased to thirty-two pounds. He was discharged in good condition and was able to eat with no vomiting.

Dr. Walton Martin stated that he had seen two instances of hernia of the diaphragm, both in adults; one was in a cadaver at the College of Physicians and Surgeons, some years ago, in which the stomach was in the left chest and the colon with the appendix was under the second rib. The second was in the service of Doctor Abbe, and the case was reported by Dr. Karl Vogel; in this instance the colon was also, with the stomach, in the left chest. Both patients reached adult life and both gave the appearance of being well nourished. The first was stated to have died of tuberculosis, the diagnosis having been based possibly upon the sounds heard in the chest emanating from the colon and stomach. The other patient had no digestive difficulty and died of peritonitis following diverticulitis of the sigmoid.

COMPOSITE TUMOR OF THE PAROTID.

Dr. Walton Martin presented a woman, fifty-four years old, who was operated on by him at St. Luke's Hospital in September, 1917. She was suffering at that time from a composite tumor of the parotid. The tumor was about 2½ inches in one diameter by 1½ inches in the other and presented the usual characteristics of this type of tumor of the parotid.

Under ether anæsthesia the tumor was removed through an incision following the outline of the posterior and inferior borders of the mandible and then dissecting up the skin sufficiently to expose the tumor imbedded in the parotid. The tumor and its capsule were removed at the operation. The wound healed by primary union; but after about ten days a soft, painful swelling made its appearance in the parotid at the part of the gland where the tumor had been removed. A needle introduced withdrew clear fluid,

evidently saliva. In a week or ten days the fluid again accumulated and only finally disappeared after seven or eight weeks. She has also complained of paroxysmal attacks of pain in the parotid since the operation.

GASTROSTOMY FOR CARCINOMA OF THE ŒSOPHAGUS

Dr. John Rogers presented a man aged fifty years, who came to Bellevue Hospital in January, 1918, presenting the typical picture of an obstruction at the cardiac orifice of the stomach. This in a short time became complete, and on January 19, 1918, a Janeway gastrostomy was performed, and the condition ascertained by exploration to be a carcinoma of the lower end of the œsophagus and the upper end of the stomach. This was inoperable. The gastrostomy was performed by cutting a rectangular flap three inches long and two inches wide at the greater curvature from the anterior surface of the stomach. The gap in the stomach was closed by uniting the sides of the two-inch gap and then folding the flap together in the shape of a cylinder. The cylinder connecting with the interior of the stomach was then turned out through a stab wound in the left rectus muscle, and sutured to the skin so that the mucosa projected a half inch beyond the skin surface. This gastrostomy does not leak, and if the bit of stomach projects far enough from the skin it does not close. A full description of the operation can be found in Doctor Janeway's original report.

EXOPHTHALMIC GOITRE

Dr. John Rogers presented the following patients:

Case I.—Mrs. C. S., aged twenty-one, when first seen in July, 1911. She then presented a small cystadenoma of the lower pole of the left thyroid lobe 2 inches in diameter. The right lobe and the isthmus were perceptible only. She gave a history of having grown up rather rapidly, of always being tall and thin and easily fatigued, and on the least exertion or excitement complained of some breathlessness and tachycardia. When quiet the pulse and all symptoms were normal. Her chief complaints were frequent headaches, weakness and fatigability, and dry skin, constipation and gaseous indigestion. These were interpreted as evidences of hypothyroidism. Under thyroid feeding with tablets containing 2 per cent. of the coagulable thyroid proteins, she improved somewhat in strength and had less headache. Later, after stopping the tablets and undergoing much fatigue in rather strenuous household occupations, she suffered from a rather pronounced rapid pulse, loss of flesh, sweating and loose bowel movements. During this period there were no headaches. In other words, the chronic hypothyroidism was followed, in this case, after fatigue by a rather typical hyperthyroid disturbance, but without exophthalmos. By rest and medical treatment this gradually improved until the condition of constipation, headache and fatigability returned. In the intervening seven years until the present time she has repeated this story quite frequently. In other words, this patient is a chronic hypothyroid subject, but has suffered repeated attacks of hyperthyroidism. At present, she shows

a mild hyperthyroidism. The cystadenoma in the right lobe of her thyroid has gradually increased in size, and is now four or five inches in diameter instead of two. In these cases, the gland surrounding the capsule of the tumor should show the convoluted folds of epithelium in each acinus which are characteristic of the hyperthyroid disturbance. The gland, however, which is a little further removed from the tumor, should show only the slightly enlarged alveoli of a "simple goitre," and the excision of the tumor will cause all the hyperthyroid changes to disappear and she will resume her condition of mild chronic hypothyroidism, which is easily relieved by thyroid feeding. Apparently, as time goes on, the thyroid gradually becomes able to do its duty, especially if assisted by thyroid feeding, and she will eventually become a perfectly normal individual, although always having physical limitations which are connected with fatigue. Any extreme of work or worry will for many years give rise to symptoms which can only be interpreted as those of hypothyroidism.

CASE II.—Man, aged twenty-four years, was first seen in May, 1917. He gave a history of having studied very hard in preparatory school and in the City College, and of pain which began in the region of the thyroid, in 1911, and was intensified by work or study. The gland, in 1912, began to enlarge, and in 1913 he suffered from some tachycardia and some pain in his eyes. He apparently had a mild hyperthyroidism, with a slight enlargement of the right lobe of the thyroid and with more or less ache or a choking discomfort in this region. He was operated in August, 1915, at St. Luke's Hospital, and had the right lobe of the gland removed. The pain persisted in his neck, although the discomfort in his eyes and the tachycardia gradually disappeared in the course of the succeeding year. Ever since 1916, however, any considerable exertion either mental or physical increases this pain in his thyroid region, and he has noticed that his mentality has not been capable of prolonged work. That is, he cannot study or remember as well as he used to. Thyroid feeding with tablets containing 5 per cent. of the coagulable proteins seems to relieve this pain to a certain extent, but never completely except when his mind and body are entirely at rest. That is, fatigue of any kind seems immediately reflected to his thyroid region, and is manifested by a pain which he locates in the isthmus of the gland which is relieved by rest and thyroid feeding.

CASE III.—Man, aged thirty-three years, was first seen in December, 1915. Gave a history of hard work and attacks of sciatica with muscular weakness, which began in 1913. He first noted exophthalmos in May, 1915, and a little later a "goitre" was observed. He then spent several weeks in Roosevelt Hospital under medical treatment, and during the summer of 1915 went to the country and gained 40 pounds. After returning to work in the Fall, he lost this weight and several pounds in addition. In December, 1915, he presented himself with marked exophthalmos and perceptible thyroid enlargement, a blood-pressure of 140, a pulse-rate of 100–120, a weight of 106, and rather pronounced emaciation with a fine tremor in the extended fingers. The skin was

pale and dry, the bowels constipated. Sympathetic atonia. An experimental test with thyroid feeding intensified all his symptoms. He was then put through the calorimeter by Doctor DuBois, in Bellevue Hospital, and was found to have a normal metabolism. That is, the best test known for hyperthyroidism showed that that condition did not exist. In spite of these findings, on December 31, 1915, Doctor Rogers ligated both superior thyroid vessels and excised for examination the tips of both lobes. The report which came back from the pathologist was " simple goitre. No hyperthyroid changes to be found." Very little improvement followed the ligation until a month later, when feeding with the adrenal proteins was begun. In March, 1916, the pulse was still 100–120, but the weight had increased from 106 to 134. In October, 1916, after six months rest in the country, the weight had been changed, but the subjective symptoms had been decidedly improved. The nervousness and fatigability were much less. In July, 1917, the condition was about as at present, which means that he still presents some traces of exophthalmos; the strength is good, but he cannot undergo much nervous or physical strain without an undue amount of fatigue. This case was one in which excision of the thyroid would have resulted in a hopeless condition of asthenia.

Dr. Walton Martin said he could throw light on one of the cases presented by Doctor Rogers. He had performed a hemithyroidectomy about two and a half years ago on the patient. The indication for the operation was persistent pain in the midline of the neck and an enlargement of the thyroid on the right side. The pulse-rate was never more than 100, he had no evidences of exophthalmos, or other signs of hyperthyroidism. He made a good recovery after the operation. His pulse was 72 on leaving the hospital. Microscopical examination showed colloid adenomatous goitre. He continued to complain of pain in his neck, however, and a variety of neurasthenic symptoms. From time to time he had written long, rambling letters explaining his ailments. These letters suggested an unbalanced mentality. He had referred him to Doctor Rogers thinking treatment by organ therapy would do him no harm and might give him mental relief. As to Doctor Rogers' statement that hemithyroidectomy might do harm by inducing hypothyroidism, he had not personally seen clinical evidence which bore out this statement, certainly one saw very striking improvement and gain in weight after partial thyroidectomy in suitable cases of toxic goitres. Reports from large clinics like the Mayo's showed favorable results, that is, about 75 per cent. of those operated on report themselves as cured.

Dr. John Rogers, in closing, called attention to the fact that he did not mean that a great many cases suffered from hypothyroidism as a result of the operation, but that a good many died immediately from the effects of the operation. There are some cases in which the results were not satisfactory, *i.e.*, where the symptoms continue and where new ones develop and the patient is then classed among the neurasthenics. He suggests that when one is in doubt as to what is going to happen in any case referred to him, he would be safe to tie off the four thyroid arteries.

Stated Meeting, held March 13, 1918

The Vice-President, Dr. William A. Downes, in the Chair

MAJOR OPERATIONS UNDER LOCAL ANÆSTHESIA

Dr. Joseph Wiener presented a man of sixty-five years, who was operated on at Mt. Sinai Hospital in February, 1918. The abdomen was opened by a transverse incision across the rectus and upper part of the abdomen; the gall-bladder was found considerably enlarged with the omentum wrapped around it; the cystic duct was tightly strictured. The gall-bladder was removed, common duct opened, and a stricture found which was cut and then a little wick of rubber drain was put down to the opening in the common duct after putting a fine catgut suture in the wall of the duct. The abdomen was closed in layer sutures. Operation took forty-five minutes. This gall-bladder contained stones and so did the cystic duct. The patient had very little pain, all manipulations were made without any difficulty, and he made an uneventful recovery. He still has an opening in one angle of the wound but there is no more bile coming from it.

This is the first choledochotomy that Doctor Wiener had done under local anæsthesia, although several cholecystectomies and cholecystostomies had been done. The technic was somewhat varied in this case and it was found that the patient had pain when the gall-bladder was pulled up with the clamp from the liver bed. Therefore the local anæsthetic was injected between the liver and the gall-bladder, then into the cystic duct and around the neck of the gall-bladder. This patient, although he stood the forty-five minutes of manipulation under local anæsthesia very well, would not have stood forty-five minutes of ether anæsthesia.

As regards the preparation of patients, it is Wiener's rule to administer two doses of morphine in divided doses, ¼ of a grain being given by a hypodermic thirty minutes before the patient comes to the operating room and ¼ of a grain after reaching the anæsthesia room. With one exception every adult has required a second quarter grain of morphine and it is given in divided doses to exclude any possibility of idiosyncrasy to the drug.

This operation was done under apothesine. Apothesine and novocaine belong to the ester group; both have an amido base; novocaine is made with ethyl alcohol and apothesine with propyl alcohol. Both novocaine and apothesine are non-toxic. As regards the percentage of the solutions, 1 per cent. is that advocated by Doctor Wiener, and to this he usually adds adrenalin to prolong the anæsthesia. In some cases he has tried using salt instead of adrenalin, but it does not work so well. As regards the amounts, he has repeatedly used twelve grains of both novocaine and apothesine without any noticeable effects. He cited a rather striking example of the non-toxic effect of novocaine in a patient with appendicitis with perforation and peritonitis: A solution had been given to the patient to drink, that is, six

pale and dry, the bowels constipated. Sympathetic atonia. An experimental test with thyroid feeding intensified all his symptoms. He was then put through the calorimeter by Doctor DuBois, in Bellevue Hospital, and was found to have a normal metabolism. That is, the best test known for hyperthyroidism showed that that condition did not exist. In spite of these findings, on December 31, 1915, Doctor Rogers ligated both superior thyroid vessels and excised for examination the tips of both lobes. The report which came back from the pathologist was " simple goitre. No hyperthyroid changes to be found." Very little improvement followed the ligation until a month later, when feeding with the adrenal proteins was begun. In March, 1916, the pulse was still 100–120, but the weight had increased from 106 to 134. In October, 1916, after six months rest in the country, the weight had been changed, but the subjective symptoms had been decidedly improved. The nervousness and fatigability were much less. In July, 1917, the condition was about as at present, which means that he still presents some traces of exophthalmos; the strength is good, but he cannot undergo much nervous or physical strain without an undue amount of fatigue. This case was one in which excision of the thyroid would have resulted in a hopeless condition of asthenia.

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grains of novocaine were in the patient's stomach and he then used six grains under the skin without the slightest sign of any irregularity of the pulse. The amount of adrenalin used in an ounce of a 1 per cent. solution would correspond about to ten drops of the one to one thousand solution.

As regards the time of operation for local anæsthesia, it does take longer than under general anæsthesia, but the patients stand it very well.

In regard to the time that local anæsthesia will act, it has been the general impression of Doctor Wiener that apothesine lasts longer than novocaine, although he has nothing to prove this belief. He has done a radical breast amputation taking over an hour, using the transverse Stewart incision, and there was still skin anæsthesia at the end of the operation. On several appendectomies, however, he has found that the skin anæsthesia has gone after the expiration of thirty-five minutes.

One satisfactory thing about apothesine is that it can be obtained in this country, being made by Parke, Davis & Co., and can be purchased in tablets of 1¼ grains which require only three or four tablets for a major operation.

As to the amount of the solution used, Doctor Wiener states that in an ordinary appendectomy he can get along with one ounce; for a hernia with less than an ounce; for breast amputation it requires sometimes as much as three ounces of the solution.

Dr. William A. Downes stated that he had used a great deal of local anæsthesia, both novocaine and apothesine, but has not used adrenalin for several years, due to the fact that he found when using adrenalin there was apt to be some sloughing of the margins of the wound. He considers his results without the adrenalin quite as satisfactory as with it, so far as the anæsthesia goes.

COMPOUND FRACTURE OF BOTH BONES OF THE LEG WITH AMPUTATION

Dr. Seth M. Milliken presented a man who was admitted to Lincoln Hospital on June 25, 1917, having been knocked off a motor cycle by an automobile. He was put to bed, his fracture put up by the house staff of the hospital, and X-ray taken the next day failed to show perfect position of the fragments, therefore under ether anæsthesia reduction was done, cleaning out the wound, and partially closing it with one stitch. Splints were re-applied. Temperature rose to 100.5° and there was a great deal of hæmatoma and swelling below the site of fracture. On the following day his temperature was 102.6° and he was delirious. There was marked interference with circulation of the foot: the bandage was removed, the foot elevated, and the next day the temperature was 103° and there was obstruction in the circulation to the foot. A circular disarticulation at the knee-joint was done and he ran a very septic course, with induration half way up the thigh. He developed an erysipelas which started in his thigh, jumped to his face and extended all over his body with periphlebitis and abscess

formation over the condyles and scalp of the back of his head. A pocket was opened in the joint cavity above the patella on July 16th. He was delirious and in bad shape until July 21st, one month after admission. At this time heavy granulations covered the stump except over the cartilages of the condyles of the femur. On September 24th the epithelium had covered in the granulations up to the margins of the condyles. An aperiosteal amputation was done on September 24th, a little below the middle of the thigh, and the flaps loosely approximated. A rubber tissue drain was placed at each angle and a dry dressing applied. There was practically primary union. He now has developed a bursa over the inner margin of the femur and can bear his entire weight on the stump. He will be able to use a properly made artificial leg. He was terribly septic and it is very gratifying to obtain end-bearing stump.

DOUBLE NEPHROLITHIASIS

Dr. Allen O. Whipple presented a woman, aged twenty-eight years, who was admitted to the Presbyterian Hospital December 15, 1917, complaining of pain in both lumbar regions, but most pronounced on the right side. Skiagraphs showed calculi in both kidneys. Catheterization of the ureters gave purulent urine from the left kidney, clear urine from the right. On December 21, the right kidney was exposed and opened and four calculi, each in a separate calyx in the lower half of the kidney, were removed. Operative recovery was uncomplicated, and on January 31, 1918, six weeks later, the left kidney was operated on. It was found in a condition of pyonephrosis and was removed *in toto*. She made a smooth recovery. The urinary output was abundant. She was discharged on the seventeenth day after this operation.

SUPPURATIVE NEPHRITIS WITH CALCULUS IN URETER

Doctor Whipple also presented a man, aged thirty-three years, who was admitted on account of persistent pain in the right lumbar region, with tenderness and septic symptoms. An intermuscular incision, through the McBurney point, showed a normal appendix, but with a cæcum in the region of the liver. In the region of the kidney, however, was considerable induration and the right kidney was enlarged. On approaching the right kidney through lumbar incision, the posterior fatty capsule was found greatly thickened, indurated and soggy. Near the pelvis, posterior aspect, there was a gush of blood-tinged fluid which appeared when the indurated capsule was broken into. The true capsule was not adherent except at one place in the lower pole of the kidney, posterior aspect, where there was a small softened focus, but did not contain pus. The entire kidney, except for enlargement and the one focus, looked normal, and exploration with a needle disclosed no stones. It was thought advisable, in view of not knowing the

function of the left kidney, to do no more than drain the right one by nephrotomy. A subsequent skiagraph revealed a calculus in the ureter at the level of the transverse process of the fourth lumbar vertebra. At a second operation the ureter was exposed by mobilizing the ascending colon. The only way in which the pelvis and ureter were found was by identifying the lower pole of kidney and duodenum. The stone, 2 x 5 x 3 mm., was rough, dark, and impacted in the first centimetre of the ureter. It was with difficulty disengaged. Urine followed from ureter as soon as it was removed. Vertebrated probe passed down and up ureter easily. Twenty-five days post-operative there was damming back of pus in anterior wounds, so they were enlarged under gas. Meatotomy next day after a ureteral catheterization which showed retention of cloudy urine in pelvis of right kidney. Repeated fourteen days later with same result. Recovery stormy. At the present time, there are no urinary disturbances and his general condition has greatly improved.

DR. WILLY MEYER stated that frequently nephrolithiasis is found to be bilateral. The question will arise, if we have a nephrolithiasis plus stone in the ureter on one and the same side, or nephrolithiasis on one side and stone in the ureter on the other side, which of the troubles should be operated upon first? He suggests that the calculus in the ureter should always be the one chosen for the first operation, provided the patient is unable to stand both on the same side in one stage. When the operation on the kidney substance is undertaken at the second stage, there will be a functioning ureter to rely on.

Doctor Meyer considers the reported case of suppurative nephritis with calculus in the ureter as of particular interest, as the complications might have occurred in any case where one is called upon to operate suddenly on a patient stricken with chills and high fever and where suppuration in the kidney is diagnosed. He stated that a number of years ago, when X-ray work was in its infancy, he had such a case under his care; this was a woman who had been taken sick sometime before with acute renal colic and then stricken with chills and fever running up to 105° and 106°, showing great tenderness on lumbar palpation. Undoubtedly there was unilateral acute renal infection. There was no time for radiographic and cystoscopic examination. He therefore cut down on the kidney primarily and found a number of larger and smaller abscesses throughout the parenchyma of the kidney which showed the colon bacillus in pure culture. Not knowing the function of the other kidney, he of course could not remove this kidney. He therefore made two-thirds of a section cut of the central part of the organ. Having entered into the pelvis he kept the two halves separated by a drain and several tampons. To his astonishment, this patient pulled through with a well functionating kidney. X-rays and ureteral catheterization done later demonstrated, as cause of the disease, a stone in the ureter wedged in where the uterine artery crosses the ureter. When this stone was removed the kidney drained normally.

THE USE OF CHLORINE ANTISEPTICS IN CIVIL HOSPITALS

DR. JOHN A. HARTWELL read a paper with the above title, for which see page 385.

DR. A. V. S. LAMBERT stated that the Dakin fluid had had certain advantages which Doctor Hartwell had brought out clearly in the action that it has on dead tissue in the wound which none of the other antiseptics or fluids now used for bathing wounds possess. His experience with traumatic cases has been very satisfactory and the problem here is one of placing the tube in such a way as to have the fluid bathe the tissues. A problem which has particularly interested Doctor Lambert has been the application of this fluid to the infections that are due to bacterial invasion coming from the blood stream or from the intestinal tract or some other avenue rather than from a visible large lacerated wound. He stated that a considerable number of osteomyelitis cases had been treated this winter with this fluid and the impression has been that suppuration is controlled better by the use of the Dakin solution than by any other method up to the present time. The bone is not bathed so continuously in purulent fluid and there has not been the progressive necrosis or the formation of small sequestra to the same extent as in cases before the use of this fluid. Doctor Lambert considered Doctor Hartwell's suggestion that possibly the result might be just as good if the same amount of trouble were taken with other material as that expended when Dakin's solution was used, one which might bear investigation. There is one point about the dressings to which he called attention; that is, after the third day they are practically painless. The dressing can be carried out with much less discomfort to the patient than under the old form of packing and removing of drains of gauze or other material. The patients suffer less under the treatment and in osteomyelitis cases it has been particularly noticeable.

At the Presbyterian Hospital Doctor Rulison has started in to treat appendix cases with abscess and the problem he has been working on is the action of this fluid in the peritoneal cavity and the possibility of introducing it to the depth of the wound in the presence of rather recent adhesions thrown out about a tube or drainage. In a few cases which he has been studying, he has met with success. He has attempted a different arrangement of tubes which will ensure the free exit of the fluid, and a temporary bathing of the wound rather than puddling the fluid in it.

Doctor Lambert stated that he had used this fluid in wounds resulting after the section of the large intestine where instead of sewing up immediately the superficial subcutaneous tissue and skin he left it open, put the tubes with the fluid on them and by this treatment prevented suppuration in these wounds.

He has not had a great deal of experience with dichloramine-T. He considers it a less effective dressing in wounds where suppuration and inflammation is well established.

Dr. Walton Martin stated that to understand the value of the Carrel-Dakin treatment one must keep in mind that two distinct processes are employed. First, there is the mechanical cleansing of the wound if contaminated or the necessary surgical procedure in well-established infection; and second, the application of the antiseptic according to carefully thought out rules.

In a recent gunshot injury, if the necrotic and devitalized tissue along the entire track of the missile is excised, the wound is changed from a heavily infected lacerated contused wound to an incised wound slightly infected. Carrel gives the credit for first carrying out this excision to Depage and his school, and from results published by Depage convincing evidence is given of its importance. In gunshot injuries of the knee, for example, Depage reported that from 1915 to 1916 he used the complete technic as advised by Carrel and he had far better results than before its use. After July, 1916, however, after excision of the bullet track, he systematically adopted immediate closure of the wound track even in cases of extensive osseous lesions, and no antiseptics whatever were used, and yet since he had adopted this method his results had been far better than when he used the full Carrel treatment—80 per cent. recoveries with restoration of movement, whereas under the Carrel-Dakin method he had only 40 per cent.

But in treatment of fractures of the long bones he has followed with excellent results the full Carrel method. In 1917 he reported 75 cases closed secondarily after treatment from fifteen days to a month. The regular introduction of the Dakin solution possibly aids in the elimination of areas of necrotic tissue and minute foci of infection which might readily escape detection in the excision of the tissue about the entire bullet track in these extensive injuries.

In regard to the introduction of this method where infection is well established in civil hospitals, Doctor Martin called attention to the well-known fact pointed out by Doctor Carrel himself, that no antiseptic can possibly have any bactericidal property unless it comes in intimate contact with the microörganisms. This is well exemplified in the treatment of long established suppurative osteomyelitis; the Dakin solution simply keeps the wound surface clean, cleaner than any antiseptic Doctor Martin had ever seen used, but unless the treatment was joined with well considered surgical procedures it must necessarily be ineffective.

Doctor Martin once more emphasized the two essential features: first, the mechanical procedure according to generally recognized principles of surgery; second, the systematic flushing of the wound with the Dakin solution, the latter in many instances a very valuable adjuvant.

Dr. Alexis V. Moschcowitz stated that up to the early part of last summer he, after having tried out as he considered faithfully, the Carrel-Dakin technic, had abandoned it because of his extremely poor results.

He, however, went to the Emergency Hospital shortly after it was opened and there learned that his results had been poor because he had not understood the technic as it should be employed. Since that time he has again used it at Mt. Sinai Hospital and is now a decided advocate in its behalf, believing it to be a most excellent treatment. He described three cases of osteomyelitis in which excellent results were obtained, several cases of abscess of the breast and some instances of other subcutaneous abscesses and infections of various kinds.

Dr. William A. Downes inquired if Doctor Lambert in the use of this method in abdominal sinuses had experienced the formation of fecal fistulæ. He referred to an instance in which dichloramine-T was injected into the sinus of an old suppurating abdominal wound where the intestines had not been at all injured at the time of operation and where in the course of two or three weeks a fecal fistula developed. He also had heard of one or two other similar instances and questioned whether the selective action of this fluid for necrotic tissue was responsible for this result.

Dr. A. V. S. Lambert in reply to Doctor Downes' query recalled a case of large intestine resection drained in the ordinary way to the site of the anastomosis. The resection of the transverse colon was done for carcinoma and the drainage was removed on the sixth day, remaining out for two days. At this time suppuration occurred and a small tube was again inserted through the sinus and Dakin's solution run in; the following day there was a fecal fistula and this he considered possibly due to the use of the Dakin fluid. He believed that Doctor Martin had had a somewhat similar instance in a case of a deep intestinal wound where two or three weeks after sloughing and the development of a small hole in the intestines resulted in a fecal fistula. He calls attention to the point that in these cases the Dakin solution lies in a deep pocket in the bottom of the wound where it has a chance to act in a way that it would not under ordinary circumstances. Its contact with soft tissue, such as coils of intestine, held together by fibrin in the early stage of repair, affords a possibility for absorption of the plastic exudate which has not become vascularized, and this results in the formation of a fecal fistula.

Dr. F. S. Mathews referred to a case where he had somewhat contrary experience. This was in an acute appendicitis operated upon a year ago and which six weeks ago returned to him with the story that a sinus had persisted ever since his operation with discharge of abundant pus; he thought this might be due to a sponge having been left in the wound and on this supposition he had to do quite an extensive operation to expose the site of the trouble: He was unable to find any definite cause for the discharge except that the small intestine showed definite miliary tubercles. He closed the opening in the cæcum, placing a drain to the bottom of the cavity, but feared a fecal fistula, as he had practically done nothing except to enlarge the opening. Ten days or two weeks later he injected

dichloramine-T and finds that at the present time the man's wound has nearly healed and he is in excellent condition.

Dr. J. A. Hartwell, in closing, stated that they had had something over two hundred cases that could duplicate in every respect all those mentioned in the discussion. He purposely said nothing in his paper relative to the technic beyond stating that at Bellevue they had followed in every detail the Carrel technic. He considered that the failures were due to the presence of necrotic tissue at the bottom of the cavity. No antiseptic will do any good in such instances. He also called attention to one very noticeable failure in a boy with a bad trauma on the inside of the thigh which was cleaned up thoroughly and the Dakin treatment started. At the time of admission he had a very severe lymphangitis and at the present time is dying of a general septicæmia; the treatment with the Dakin solution did not in any way prevent the entrance of the bacteria into the blood. He mentioned another case of a fecal fistula in a tuberculous kidney where it was impossible to determine whether he was dealing with a perforated diverticulum or kidney tissue. The kidney was cut out and the wall of the descending colon exposed, and the patient developed a fecal fistula due to the packing used to control the hemorrhage. The Dakin solution kept the wound externally clean. It was a large open wound and as far as the action of the Dakin solution on the intestine was concerned it kept the fecal passage clean. This fistula was later curetted and healed. The hypochlorite solution only acts as such on any tissue where it comes in contact for six or eight minutes. It was found in filling a cavity with this solution that the action was practically *nil* at the end of seven minutes. It is then converted into the dichloramine which exists for possibly two hours. Then the hypochlorite solution is again injected. Its action is explained by the fact that it kills the bacteria on the surface, prevents recontamination, and when the dichloramine is formed it calls out the body defenses, bringing out the blood and the leucocytes and the fluid antibodies. In so far as it does this, it is the most ideal antiseptic we have. He then cited one or two instances of fecal fistula treated with dichloramine-T, calling attention to a case of fecal fistula following resection of the cæcum for carcinoma. This had apparently healed well but a sinus burrowed under the abdominal wall. This was cleaned out entirely and dichloramine was dropped in by using a pipette and the opening in the cæcum healed with great promptness. Another case was one where a fecal fistula persisted for eighteen months after operation. A long sinus was dissected out and only a thickened fibrous cord found and dichloramine-T was put into it with very prompt healing.

In closing his remarks Doctor Hartwell wished again to emphasize the points which Doctor Martin had brought out and to state as before that every detail of the Carrel treatment was carried out according to his technic. It cannot be hoped that this antiseptic will do any good unless the proper surgery is done to begin with.

RESECTION OF STOMACH FOR ULCER

Stated Meeting, held March 27, 1918

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

RESECTION OF STOMACH FOR ULCER AFTER POLYA-BALFOUR METHOD

DR. HERMANN FISCHER said that Polya, in 1911, described an anastomosis between the intestine and the stomach, side-to-side and retrocolic. Balfour has modified the method by using the anterior gastro-enterostomy, taking a long loop of the jejunum. Doctor Fischer has used this method in four cases and has been much pleased with the result. He stated that the whole incision of the stomach can be united to the jejunum, or only a part of it, using only the lower half of it if so desired. He has had three cases with good results and now presented a case in order to get the opinion of others in regard to the method. The patient presented was suffering from a peptic ulcer; an X-ray picture showed that he does not even now completely empty his stomach after six hours, but it has been noticed that after gastro-enterostomy there is often some insufficiency in motility of the stomach without giving the patient any discomfort.

He called attention to a technical point which was to make the muscularis suture attaching the jejunum to the stomach before cutting off the stomach. In his first case he put on a large clamp and had some trouble in inserting his first row of sutures, but with this precaution he believes the operation will be made much simpler and more satisfactory.

DR. WILLY MEYER stated that he had had occasion to do the Polya-Balfour method three months ago in a patient who evidently had a chronic ulceration at the lesser curvature attached to the lower part of the liver. She had suffered intensely for months and was operated upon by means of midresection of the stomach. The proximal stump was short, also the distal; end-to-end union out of question; also osteoplastic resection of the costal arch in order to facilitate the technical procedure. In this case Doctor Meyer followed the Polya-Balfour method, taking a coil with a long mesentery, perhaps two feet from the entrance of the jejunum into the general cavity, and turned this over the omentum and transverse colon and attached it to the cut in the stomach. The stomach wound was oblique and the anastomosis fully six inches long. This patient made the smoothest imaginable recovery. There was no vomiting after the second day. He believes the explanation of this is that the jejunum, having been anastomosed in such a way that its afferent part is attached to the lesser curvature, and naturally the efferent to the major, will push down till all the food is put into the stump of the stomach. Doctor Meyer believes Doctor Balfour's modification of the Reichel-Polya anastomosis will be of great service in many cases.

SUCCESSFUL REMOVAL OF BREAST, UTERUS AND KIDNEY IN THE SAME PATIENT

DR. W. S. SCHLEY presented a woman who was admitted September 20, 1910, operated September 21, 1910, discharged October 25, 1910.

About six weeks before her entrance she noticed a mass the size of a walnut in right breast, outer hemisphere. It had increased in size up to admission. Axillary glands palpable, supraclavicular negative. Complete amputation with grafting. Glands not involved.

Four years later, September 1, 1914, she was admitted again with a general friable cauliflower growth of the cervix uteri, with extension to vaginal wall on right side. There appeared to be an extension of infiltration from cervix laterally into both broad ligaments. No enlarged lymphatics palpable. Operated September 4, 1914. Pan-hysterectomy; extensive dissection carried up to iliac glands and uterus and vaginal vault removed *en masse*. Following operation there was no urine passed and cystoscopic examination with ureter catheterization showed both occluded about 5 cm. from bladder. The abdomen was opened again under gas-oxygen anæsthesia and it was found that, curiously, the ureters had been caught by the continuous whip stitch closing the peritoneum over the operative area—great care had been taken on account of the extensive dissection to identify the ureters throughout the operation, but on account of the removal of the vaginal vault and deep suturing they were both picked up in the closing stitches. It was a simple matter to release the obstruction. The following day 34 ounces of urine were passed. The fourth day following operation urinary leakage appeared in the vagina with the serous drainage, although it could not be demonstrated on releasing the ureters that they had been wounded by suture needle. It was determined again that there was partial obstruction of right ureter 10 cm. from bladder. Notwithstanding urotropine and soda benzoate and other measures, the patient developed a pyelonephritis inaugurated by a chill on the ninth day. The condition never entirely subsided and because of the urinary findings nephrectomy was done about two months later. The patient has been in perfect health since her discharge from the hospital. It is to be regretted that the wound in ureter was not recognized at the time of its release and bladder implantation done. Following the urinary leakage the ureter and kidney infection developed so quickly that we were forestalled in that direction. It is now nearly four years from the last operation and eight from the first, but there have been no signs of recurrence in either field.

WIRING OF FRACTURED OLECRANON

DR. WILLY MEYER presented a man of fifty-six years who fell on his right elbow, sustaining a transverse fracture of the olecranon with capsular tears. Open treatment was decided on, March, 1916. It is important when intending to wire to allow the patient to wait about a week, even when one

is sure of the asepsis in the operating room. At the expiration of this time the lymph stomata have become clogged and there is less possibility of infection during the operation. With a convex incision this olecranon was wired just as a patella is wired. The man has obtained a good function. Doctor Meyer is a firm believer in the use of silver wire and has adhered to it in a series of over eighteen cases of patella fracture. The objection frequently voiced in regard to it, that it sometimes acts like foreign body, he has seen exemplified when the alloys of silver have been used; so he therefore uses only pure silver wire. He mentioned the possibility of refracture when using kangaroo tendon or chromic catgut, especially when the fragments are not brought into perfect apposition.

Dr. Lucius W. Hotchkiss stated that he has seen some of these cases suffer from too early attempt at passive motion. If the olecranon is sutured and put up at a proper angle of flexion it will stay, but too early attempt at passive motion may tear through the suture. The fine silver wire also may break or tear through. He has found less difficulty if manipulation is left until later and always puts the elbow up in flexion.

Dr. J. M. Hitzrot said that he began passive movements of the elbow in his cases of fracture of the olecranon at the end of ten days, very gradually increasing the arc of motion and being careful to do so within the limits of pain. He considered the use of wire as unnecessary. The problem is quite similar to that in fracture of the patella. When the expansion of the triceps tendon is torn, separation of the olecranon fragments must be overcome by direct fixation and suture of the torn expansion, as in the patella fracture. Doctor Hitzrot could not use the term " perfect result " as applied to Doctor Meyer's case, as the man shows a distinct loss of power in extension, and a loss of about 10 per cent. of the arc of complete extension. Loss of the power in complete extension occurs in practically all of these fractures and complete extension is rarely obtained.

In all his cases, Doctor Hitzrot used a kangaroo tendon suture passed through the triceps tendon close to the olecranon, and fastened to the ulna below the fracture by passing it through drill holes in the bone. When this is drawn taut, the fractured surfaces come into complete apposition and remain there. The torn expansion is then approximated by chromic sutures and the arm put up in extension with an anterior moulded plaster splint.

With regard to Doctor Meyer's statement regarding silver wire, Doctor Hitzrot could not agree.

After much investigation, Doctor Hitzrot found the brown iron wire used in the trade to bind bales of hay, brooms, etc., to be the strongest, cheapest and most serviceable. It is a malleable wire and comes in different sizes. It causes no more irritation than the more expensive wire, and, when required, will stand a very much greater strain than any of the other varieties, including the galvanized wire. Doctor Hitzrot has one case in a fracture of the humerus in which two pieces of wire have remained buried in the bone for a period of over six years without causing any

difficulty. In animals, the wire has exhibited exactly the same amount of irritation as is shown by silver, copper, and various alloy wires.

Dr. Robert T. Morris inquired as to the formation of general adhesions in these joints with a resulting ankylosis, and stated that he in several instances had thought it necessary to inject artificial synovial fluid into these joints to overcome such adhesion.

Dr. Royal Whitman thought that after suturing the olecranon, unless there were indications to the contrary, the arm should be placed in right angular flexion at the elbow. This attitude is more comfortable for the patient. It lessens the danger of œdema of the hand and it permits some functional use during the period of repair.

Dr. Willy Meyer, in closing, stated that he considered the question of after-treatment of vast importance. He believes the open operation in fracture of the olecranon or of the patella is frequently absolutely necessary to remove the interposition of a piece of tendon or periosteum which prevents the thorough approximation of the two fragments in many instances. In wiring these fragments of patella or olecranon he does not, however, believe in placing too much reliance upon the strength of the wire as such, and has therefore always followed the rule to first get healing of the fracture, with the extremity in extended posture, 180°, allowing say four weeks for such healing to take place. The bony callus will by this time hold the two fragments firmly fixed. At the end of four weeks he allows a patient with patellar fracture to get up, and begin active and passive motion. The latter is also done in cases of olecranon fracture. With patience they finally obtain perfect motion or at least useful limbs. With a perfect healing of the fracture assured, he believes it takes from three to four months before these patients get perfect extension and flexion.

Doctor Meyer said in response to Doctor Whitman's questioning, he relied upon the final result in a fracture, and whether of the olecranon or patella considered that this should be the criterion. He believes that after wiring a fracture the extremities should be put up in a position where there is no tension and for this reason he uses the extended position and is perfectly satisfied if the patient after three months gets perfect function or a useful limb rather than to put them in flexion and attempt to get motion in three weeks. He agrees that when they are put up in the right angle position it may take less time to get proper function. But perfect bony union may not have been obtained in the flexed position of the limb. The *final* result is the one to be worked for.

In answer to Doctor Morris' question he stated that as far as he knows ankylosis of the joint is principally caused by the amount of blood remaining in the joint; if at operation all liquid and coagulated blood is removed from the joint no ankylosis should occur. Naturally, there will be frequently some stiffness from non-use. Practical results, however, show that the four weeks rest does not interfere with the final good function of the arm or leg.

APERIOSTEAL AMPUTATION STUMP

Dr. Willy Meyer presented two men who had suffered from thromboangeitis obliterans. One, thirty-three years of age, had been treated at the Post-Graduate Hospital where his femoral vein had been tied by Doctor Heyd. He had had a necrosis of the metatarsal bone of the small toe. When he came under Doctor Meyer's observation he still had a great deal of pain, particularly during the night, and after having treated him with hypodermoclyses for some time and the wound not improving, Doctor Meyer re-operated on the metatarsal bone, although he had little faith in the procedure. The patient's foot showed no tendency to heal. After a while amputation was called for, although the pains were much less severe. Doctor Meyer made use of the aperiosteal method, viz.: instead of forming a periosteal flap as formerly done, the bone is sawed through beyond the periosteal division. About an inch and one-half of bone is left bare of periosteum and this part of the medulla of the bone is scraped. Then these patients later have an absolutely painless stump which is end-bearing.

The second case was a man thirty-eight years of age who came under Doctor Meyer's care in May, 1916, for the same trouble. At that time there was gangrene of the big toe, and after the use of hypodermoclysis of Ringer had brought some relief, there was still so much pain that removal of the toe was indicated. The patient was advised at this time to have a thigh amputation, but this he refused. He showed little, if any, improvement, and ligation of the femoral vein in Scarpa's triangle was done on May 25, 1916. The toe with a portion of the metatarsal bone had also been removed a few weeks previously and the patient returned home; but the wound did not heal. Three weeks later amputation of the thigh became necessary. The same procedure was followed as in the former case, and also, making rather large skin flaps should a part of them become necrosed. After eight or ten weeks the patient was discharged with a small sinus. Three months later the latter was still present and prevented the use of a peg-leg. He then developed an acute lymphangitis, and inside of a week the sinus which had persisted for weeks and weeks closed spontaneously, an observation which Doctor Meyer has had in a similar case before.

With regard to the construction of the peg-legs used temporarily, Doctor Meyer stated that each one naturally is somewhat different. The benefit from the new construction of artificial limbs is that the patient now *stands* on two legs instead of riding on his pelvis and swinging the stump of the amputated leg. In the second case just reported there is the same condition in the other foot which makes it impossible for the patient to walk very far.

A woman was presented who had suffered with a tuberculous inflammation of the right tibiotarsal joint, this inflammation having lasted six years. Unfortunately, there was alongside one of the tendons an ascension of the

tubercular infection to the middle of the leg. Doctor Meyer amputated the tibia and the fibula, leaving an aperiosteal stump on both bones and using secondary suture of the wound. Primary union. This patient was able to get her peg-leg three weeks after amputation, which was changed in December to an artificial leg constructed for end-bearing.

TREATMENT OF PENETRATING GUNSHOT WOUNDS OF THE CHEST WITH HEMORRHAGE INTO THE PLEURA

DR. L. W. HOTCHKISS read a paper with the above title, for which see page 707.

DR. WILLY MEYER stated that years ago he treated a slight dagger wound of the lung in which, although there was some hæmothorax, everything went very nicely. He referred to Doctor Hotchkiss' statement that in the second case reported emphasis was laid on the cleaning out of the pleural cavity, and Doctor Meyer considered that, if this had been done from the start thoroughly, it might have simplified the further course of the case materially. Personally, he thinks that if there be a hæmothorax and compression of the lung with no change in pulse, respiration or temperature, the patient should be left alone. But if the thoracic cavity is filled with a large amount of blood clot and there is tendency to infection he would not hesitate a moment to make a long intercostal incision which would allow the surgeon to inspect the thoracic cavity and to clear out every bit of what is in there. If the case were very much infected perhaps washing might do some good, but he believes the thoracic cavity is in that respect not different from the peritoneal cavity, where the majority of surgeons have given up washing as a necessary procedure. He strongly advocates in every case thoracic drainage, that is, the post-operative thoracic drainage. He is convinced that this is the best way to treat every infected thoracic cavity no matter for what purpose. He also advocates the closure of the main incision, as in the peritoneum, making a stab-wound for drainage, using Kenyon's method.

DR. ROBERT T. MORRIS stated that when hemorrhage from the lung was continuous it might sometimes be stopped by the injection of nitrogen gas directly into the chest cavity. He also called attention to the fact that not only blood-clot might be present but also lymph-clot in the chest cavity, and these clots should be removed with great care, usually with difficulty even through a large opening. He referred to three cases in all of which it was difficult to get out the clot and in these he used a solution of pepsin and was thereby able to liquefy and drain out quantities of clots.

DR. HERMANN FISCHER stated that he had seen a great number of shell wounds of the chest and gunshot wounds during his service at the front in 1915 and 1916, and stated that the treatment depended largely upon the weapon with which the wound was inflicted. Rifle bullet wounds of the chest heal quickly. The patients were usually given morphine and an ice-

bag applied to the chest, and, as a rule, they made satisfactory recoveries. He mentioned the fact that some through-and-through shot wounds of the chest do not cause much anxiety. Shell wounds, however, are an entirely different matter and comparatively few soldiers so injured by the tremendous artillery now used ever reach the field hospital, their injuries proving fatal very quickly. Doctor Fischer stated that only five such injuries had come under his observation and that usually there is a large defect in the lung, part of it being torn away, and these cases are always severely infected and complicated by gangrene of the lung. In his treatment he used the same procedures as in peace surgery, wide opening of the chest with drainage at the most dependent point. If the wound occurs in the upper part of the chest a secondary counter-incision near to the diaphragm is advocated in order to properly drain the pus. Of the five cases coming under his care two proved fatal; in one it was necessary to resect four or five ribs, but this patient recovered, losing, however, the function of the lower lobe of the right lung.

Dr. John Douglas inquired as to what symptoms should lead one to subject the patient to immediate surgical interference. In war surgery as mentioned by Doctor Fischer, the severer cases do not reach the base hospitals, usually not the first casualty station, while in civil practice a number of such cases are seen in the hospitals. He stated that he had seen a number of such cases at Bellevue Hospital in which it was difficult to determine whether the hemorrhage was continuing and justified surgical intervention. He cited an instance of a man shot in the back, with severe hemorrhage into the pleural cavity. He was in desperate condition, and an attempt at drainage seemed useless unless the hemorrhage could be controlled; this patient died before the preparation for operation was completed. He mentioned another case of attempted suicide where there was a large gaping wound about the fifth space, just missing the heart, where every time the man breathed the lung could be seen coming up and blood spurting out of the chest wound. It was obvious that something should be done and he therefore sewed up the large rent in the lung, but the man died. Considering these two instances he would like information as to how to determine which cases to operate on with regard to controlling hemorrhage, not with regard to drainage for infection which occurred later.

Dr. Lucius W. Hotchkiss, in closing, said that Doctor Fischer's report coincided entirely with the French and English reports: The losses on the field from hemorrhage and in the first dressing station from hemorrhage and asphyxia being very great. The cases considered by him were those lung shots which get through to the casualty clearing station and later to the base hospital.

With regard to Doctor Meyer's comments as to washing out the pleural cavity, Doctor Hotchkiss stated that he had no fear in washing out the pleural cavity in old cases, and stated that in chest wounds the experience in the field has been that washing has been of the greatest value in these

cases of infected hæmothorax. This was usually done by the introduction of a tube, the Dakin or normal salt solution being used.

Lockhart reports 170 cases in which there were only three cases of septic hæmothorax, and Doctor Hotchkiss stated that he had never seen such a case although he had seen a number of shot wounds of the chest developing empyema treated by low incision and drainage, some of the patients recovering and some succumbing. From his information regarding the field cases he does not believe it to be a common form.

In reply to Doctor Douglas' query, he cited a case with severe primary hemorrhage where he operated. From the hæmatoma forming over the ribs he inferred that there had been an injury to the intercostal vessels. On exploration he found and resected a shattered rib and, seeing a hole in the lung, fished out the clots, sewed up the wound, and at the end of three weeks this patient left the hospital in good condition.

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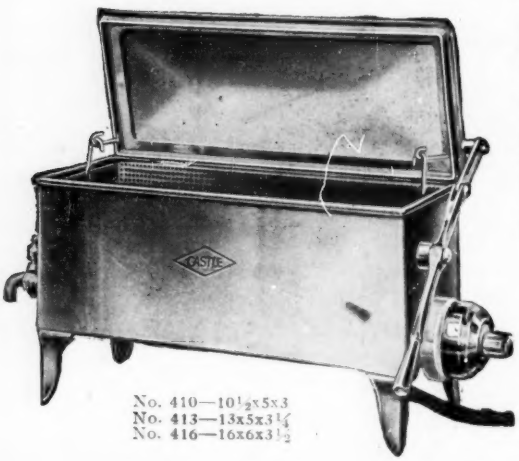

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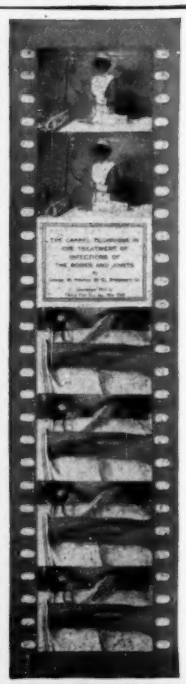

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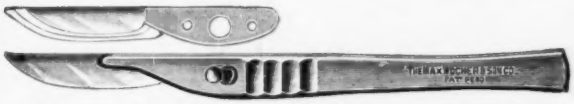

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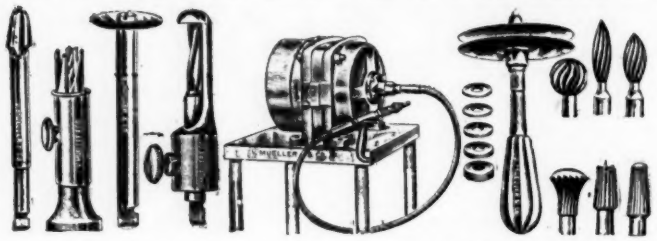

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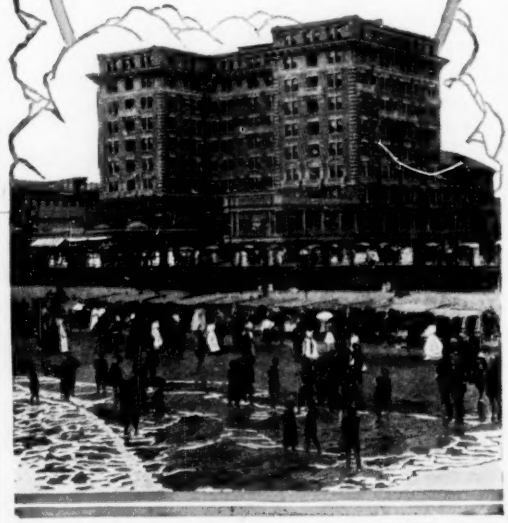

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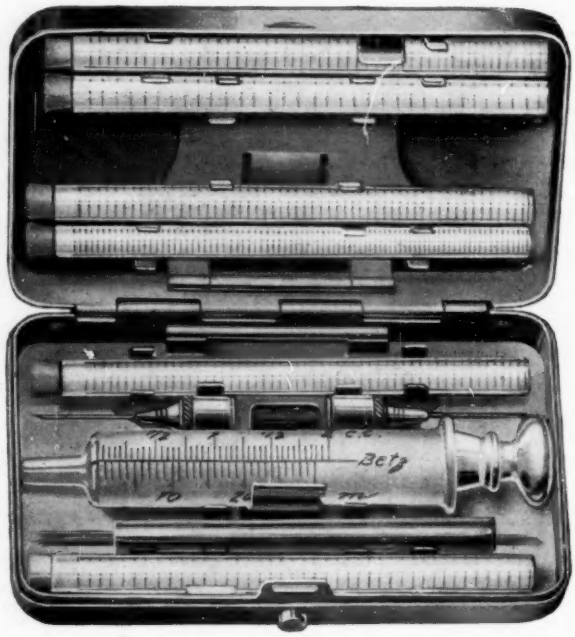

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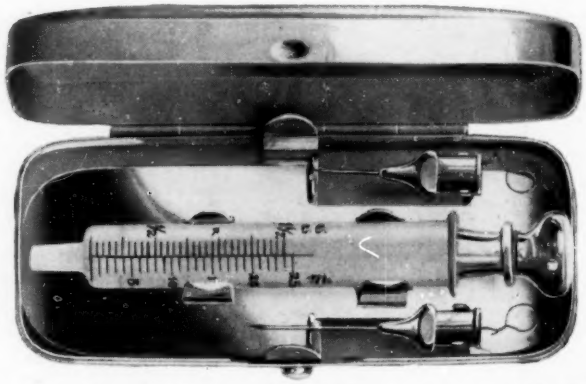

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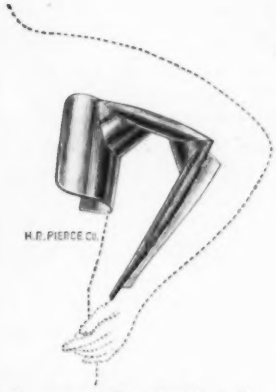

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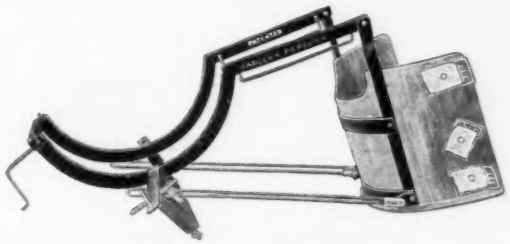

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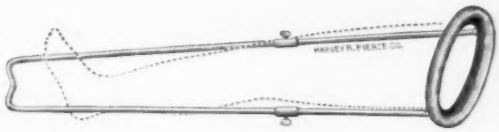

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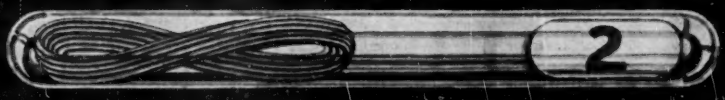

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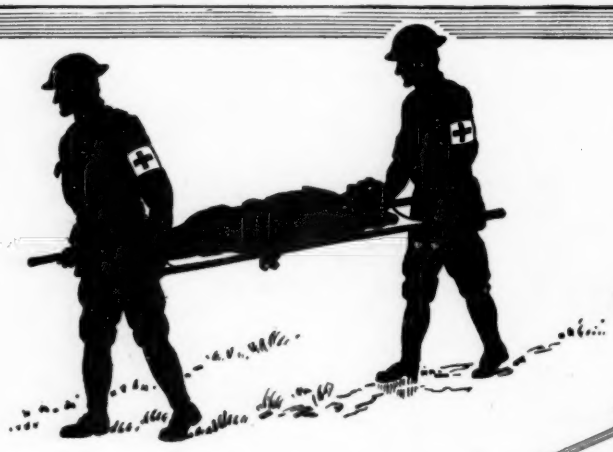

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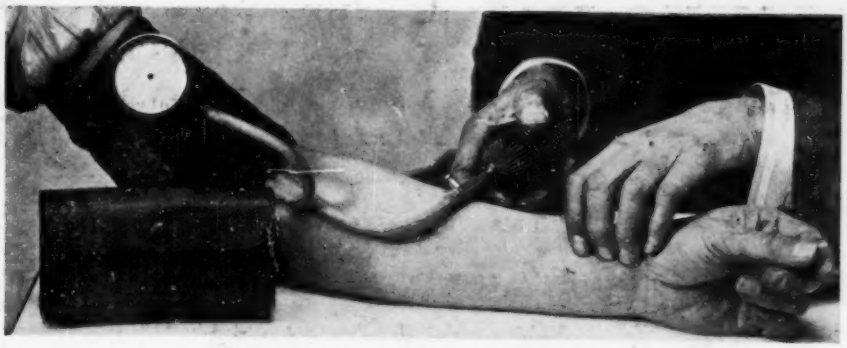

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